Georgia Tech

GENERAL CATALOG
1987-88
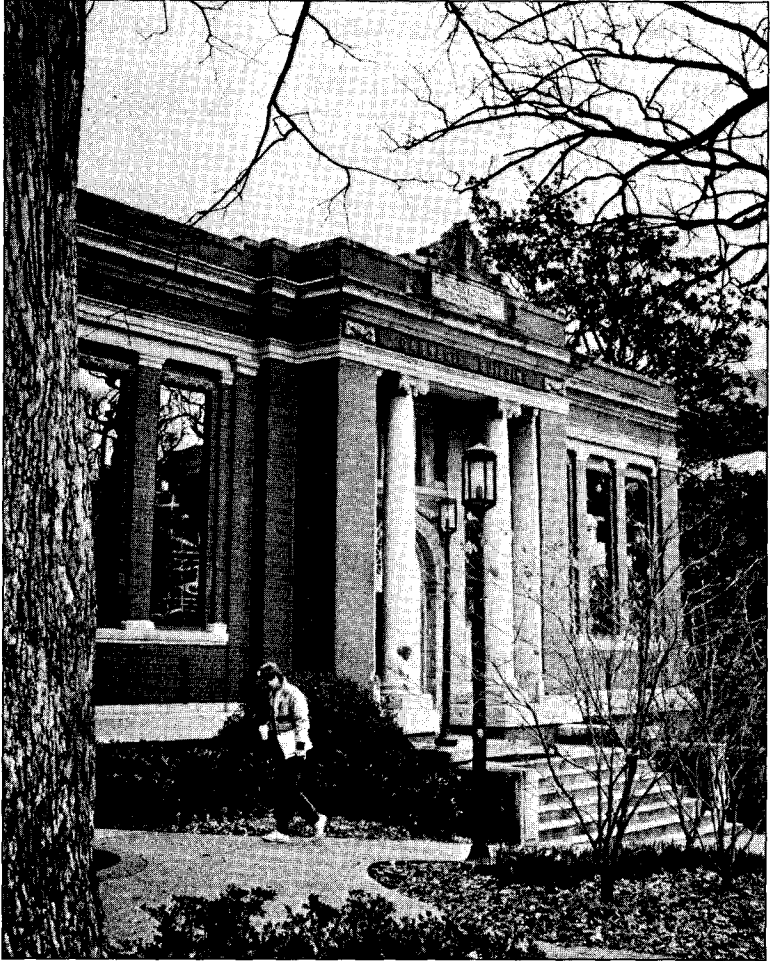
Georgia Institute of Technology
Atlanta, Georgia
General Catalog, June 1987

Contents

About this Catalog

The statements set forth in this catalog are for informational purposes only and should not be construed as the basis of a contract between a student and this institution.

While the provisions of this catalog will ordinarily be applied as stated, Georgia Tech reserves the right to change any provision listed in this catalog, including but not limited to academic requirements for graduation, without actual notice to individual students. Every effort will be made to keep students advised of any such changes. Information on changes will be available in the offices of the registrar, the dean of students, and the major schools and colleges. It is especially important that each student note that it is his or her responsibility to be aware of current graduation requirements for a particular degree program.

This institution is in compliance with Title VI of the Civil Rights Act of 1964 and does not discriminate on the basis of race, creed, color, or national origin and is also in compliance with the provisions of Title IX of the Educational Amendments of 1972, which prohibit discrimination on the basis of sex.

It is the policy of the Institute that sexual harassment as defined in the EEOC Guidelines will not be tolerated among members of the Tech community. Any complaint of sexual harassment should be reported immediately to the appropriate person or persons designated by the vice-president, dean, or director.

The cost of the 1987-88 *General Catalog* is $41,268 for a total press run of 40,000 copies.

This catalog becomes effective with summer quarter 1987.

Quick Reference Guide

Academic Calendar 1987-88

Georgia Tech operates on the quarter plan, with the fall, winter, and spring quarters normally constituting the academic year. A full summer quarter schedule offers students the opportunity to accelerate their programs by attending four quarters per year. Students may enter a course of study or complete their degree requirements and attend a commencement ceremony in any one of the four quarters.

The Office of the Registrar prepares and distributes an official Institute calendar for each quarter. Dates, filing times, deadlines, and other information contained in the official calendar supersede previously published information, including notices in this catalog. Adherence to the requirements set by the official calendar is the responsibility of the student.

Summer Quarter 1987

June 22	Registration
June 23	Classes begin
August 31	Final exams begin
September 4	End of term; Commencement

Fall Quarter 1987

September 21-22	Registration
September 23	Classes begin
November 26	Begin Thanksgiving recess
November 29	Last day of Thanksgiving recess
December 7	Final exams begin
December 12	End of term; Commencement
December 13	Begin Christmas recess

Winter Quarter 1988

January 4	Registration
January 5	Classes begin
March 14	Final exams begin
March 19	End of term; Commencement
March 20	Begin spring recess

Spring Quarter 1988

March 28	Registration
March 29	Classes begin
June 6	Final exams begin
June 11	End of term; Commencement

Summer Quarter 1988

June 20	Registration
June 21	Classes begin
August 29	Final exams begin
September 3	End of term; Commencement

Education is but a process
by which a person begins
to learn how to learn.
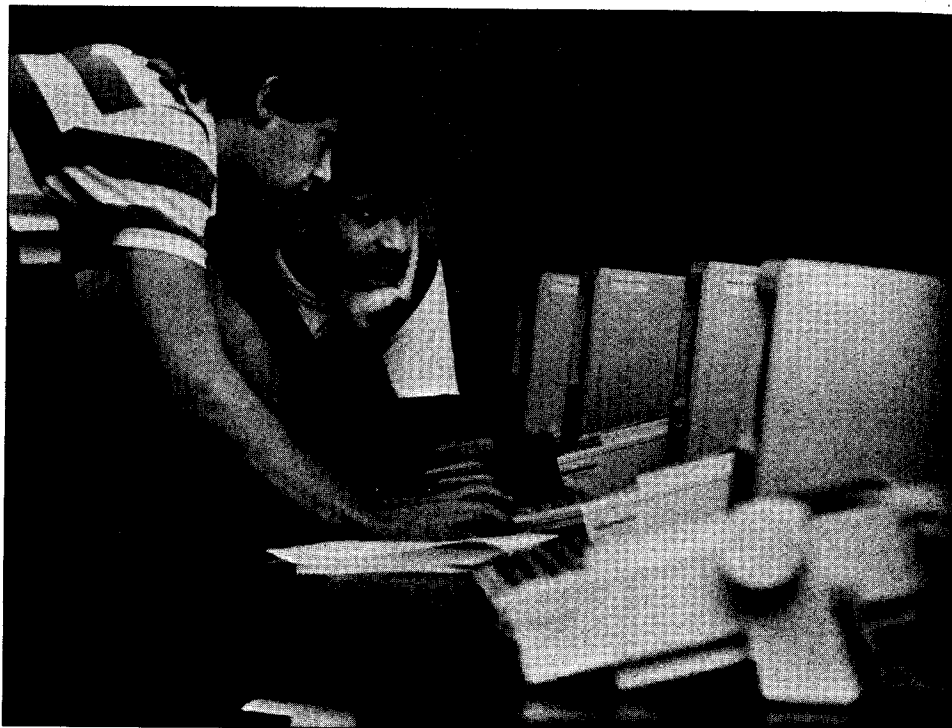
When the Georgia Institute of Technology opened its classroom doors in 1888, the concept of a technological education was still new to the South's largely agricultural society. Undaunted by philosophical opposition, the innovative forefathers of Georgia Tech boldly affirmed their belief in the necessity of a quality, technical education and thus opened the door to the future for generations of Tech graduates.

Now in its second century of excellence in education, Georgia Tech continues to pursue the goals of quality education, vigorous se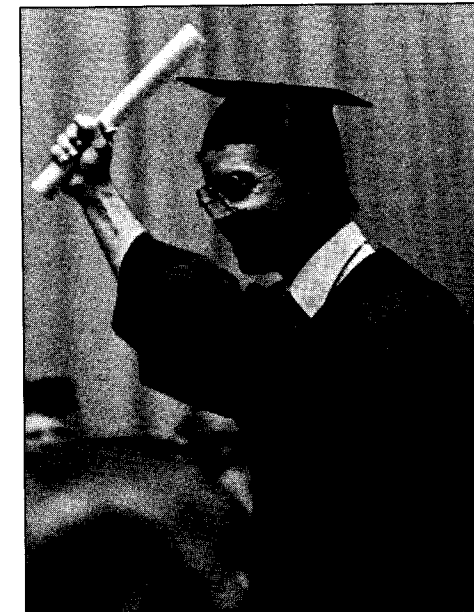rvice, and progressive research, thereby enhancing its position of national prominence. Enrollment has grown from the first class in 1888—129 mechanical engineering students, all but one from Georgia—to almost eleven thousand students from every state and eighty countries. Today, the members of this growing student community work toward undergraduate and graduate degrees in Tech's twenty-one schools and colleges. Men and women who graduate from Tech influence the worlds of architecture, engineering, management, and science; their support as alumni, consistently among the most substantial in the nation, ensures that Tech students will continue to receive the high level of technical skill that will prepare them to enter the future confidently and competently.

The Institute's primary goal traditionally has been to provide superlative instruction for capable and intelligent students. The average Scholastic Aptitude Test score for Georgia Tech students is approximately three hundred points higher than the national average, and the Institute enrolls the highest percentage of freshmen National Merit Scholars and National Achievement Scholars among publicly supported institutions in the United States. To meet the needs of these talented individuals, Tech provides a distinguished faculty, approximately 90 percent of whom hold doctoral degrees. Further, the Institute has pioneered and continues to develop innovative educational programs such as the Cooperative Plan, which offers students the opportunity to work in industry and attend school in alternate quarters.

In addition to cultivating responsibility and skill in tomorrow's leaders, Georgia Tech serves the community not only through individual volunteer efforts, but also through extensive research and service projects centered on the campus. The Education Extension sponsors frequent seminars and workshops for professionals and concerned citizens who seek to expand their knowledge of current issues. All instructional and research units, including the Advanced Technology Development Center, provide advisory services in engineering, architecture, science, and management as well as on-site development programs for industry and government.

As the South's largest industrial and engineering research agency, with an annual research budget in excess of $100 million, Georgia Tech has contributed extensively to diverse fields such as energy conservation, artificial intelligence, submillimeter waves, digital image processing, remote sensing, chemical kinetic processes, electromagnetic scattering, guidance/seeker technology, electronic countermeasures, and composite fiber structures. Projects conducted at Tech range from solar energy development to complex defense systems research. Engineers, scientists, and other technical experts in Georgia Tech's twenty-one interdisciplinary research centers, the Georgia Tech Research Institute, and academic schools and colleges explore problems such as the effects of radio frequencies on heart pacemakers and the levels of radiation in drinking water to open

new areas of knowledge to investigation. In addition to a fine library, a well-equipped computing center, and the on-campus research centers, the Institute offers its students access to a marine facility at Skidaway Island and the Oak Ridge Nuclear Laboratories in Tennessee.

The Georgia Institute of Technology eagerly anticipates the opportunities of the future. Through its dedication to intellectual excellence, the Institute will continue to provide quality education, service, and research for the benefit of its students and the larger community.

Academic Offerings

Through the Colleges of Engineering, Sciences and Liberal Studies, Management, and Architecture, Georgia Tech offers curricula leading to degrees in twenty-eight undergraduate majors, thirty-two master's programs, and twenty-four doctoral programs. The "Information for Undergraduate Students" and the "Information for Graduate Students" sections of this book contain general information about these degree programs. For more specific information, see the "Curricula and Courses of Instruction" section in this catalog.

Accreditation

The Georgia Institute of Technology is an accredited member of the Southern Association of Colleges and Schools, and many programs within the Institute are specifically accredited by appropriate national certifying agencies. The Accreditation Board for Engineering and Technology (formerly the Engineers' Council for Professional Development) has awarded accreditation to the four-year engineering curricula leading to bachelor's degrees in the following fields: aerospace engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, engineering science and mechanics, industrial engineering, mechanical engineering, nuclear engineering, and textile engineering and to the graduate programs leading to master's degrees in the following fields: aerospace engineering, ceramic engineering, civil engineering, electrical engineering, industrial engineering, mechanical engineering, metallurgy, nuclear engineering, environmental engineering, and textile engineering. The American Chemical Society has certified the curriculum leading to the bachelor's degree in chemistry; the National Architecture Accrediting Board has certified the curriculum leading to the Master of Architecture; and the American Assembly of Collegiate Schools of Business has accredited the College of Management.

The School of Chemical Engineering has an active and widely recognized program that leads to M.S. and Ph.D. degrees. This program is not included in the above list because AIChE does not accredit graduate programs at any university that offers an accredited B.S.Ch.E. degree.

Special Support Facilities

Library

The Price Gilbert Memorial Library houses one of the nation's largest collections of scientific and technical information. Its holdings in management and architecture are also significant. The resources include over 2.1 million volumes, more than 646,000 government documents, nearly 143,000 maps, a complete collection of United States patents, and approximately 2 million technical reports from government- and industry-sponsored research and development. The Library receives more than 28,000 serials, about 75 percent in scientific and technical fields. It is an official depository of the United States Government Printing Office and the United States Patent and Trademark Office.

The catalog record of the Library is on line, as part of its On-line Information System, and is available to faculty, staff, and students through the campus computer network. The On-line Information System also contains data bases that index the contents of periodicals, conference proceedings, and research reports.

Services provided by the Library include delivery of library materials to faculty and staff; tours of the facility and instruction in the use of its resources; computer searches of more than four hundred commercial and government produced remote data bases; copying facilities; fee-based services to sponsored research users on campus and to individuals and businesses outside the Georgia Tech community; access to and delivery of materials from eleven other libraries in the Atlanta area and Athens; borrowing reciprocity with Georgia State University; and entree to the libraries of all institutions in the University System.

Computing Facilities

The Office of Computing Services (OCS) is a service-oriented organization of the Georgia Institute of Technology whose function is to provide computing services in support of education, research, and administration. The central-site computing facility is open and attended twenty-four hours per day, seven days per week, except possibly on holidays. Permanent accounts issued to all students provide a universal access method for computation, communication, and information.

The central computing facility consists of a CDC CYBER 180/855, a CDC CYBER 180/990, an IBM 4381, a Pyramid 90x, and two AT&T 3B20 systems, all of which are available in both batch and interactive modes. The CYBERs run the NOS and NOS/VE operating systems. The IBM 4381 runs the VM/CMS and MVS operating systems; the Pyramid runs both System V and Berkeley UNIX; and the 3B20s run System V UNIX. In addition, support is provided for two IBM 4341s, a CDC CYBER 830, and a CDC CYBER 810, located at remote campus sites. Interactive access to these machines is provided by GTNET, the campuswide network. OCS provides 300, 1200, and 2400 bps dial-up access to GTNET. In conjunction with the College of Engineering, OCS provides support for the CAE/CAD facility computers, Xerox AI Lab, and CAD work stations.

Georgia Tech Research Institute (GTRI)

The Georgia Tech Research Institute (GTRI) is chartered by the Georgia legislature to serve the community, state, and nation; conduct scientific, engineering, and industrial research; encourage the development of natural resources of Georgia; aid industrial and economic development; and participate in national programs of science, technology, and preparedness. In performing these missions, GTRI is simultaneously making the maximum possible contribution to Georgia Tech's overall research, educational, and service goals.

The GTRI staff represents most of the recognized fields of engineering, physical science, and technology, with a full-time staff of approximately nine hundred persons, six hundred of whom are research faculty; an additional 450 faculty, students, and consultants participate on a part-time basis in the research programs.

GTRI is headquartered on the Georgia Tech campus in Atlanta. A major portion of the activity is also located at an off-campus facility in nearby Cobb County. In addition, twelve field offices are dispersed throughout the state in Albany, Augusta, Brunswick, Carrollton, Columbus, Douglas, Dublin, Gainesville, Macon, Madison, Rome, and Savannah. Other groups are performing research at the sponsors' location in Warner Robins, Georgia; Huntsville, Alabama; Ft. Monmouth, New Jersey; and Eglin AFB, Florida.

The Georgia Tech Research Institute's activities are coordinated with research conducted by the academic schools and colleges through the vice-president for Research. For additional information, contact the Office of the Director, Georgia Tech Research Institute, Second Floor, Centennial Research Building, Telephone: (404) 894-3411.

Advanced Technology Development Center

The Advanced Technology Development Center (ATDC), formed in 1980, serves as a catalyst for high-technology growth in Georgia. The ATDC assists in the recruitment of new companies to the state; aids early-stage, Georgia-based high-technology companies; and works to build the statewide infrastructure needed to support technology-based industry.

For established companies interested in locating facilities in Georgia, the ATDC offers extensive research information on Georgia's high-technology resources and assistance in gaining access to those resources. For early-stage, high-technology companies and for qualified research and development or new product development groups from established firms, the ATDC provides a battery of support services designed to help a new venture get started and succeed.

These services include, when appropriate, business planning and management assistance, access to Georgia Tech facilities and services (such as the Computing Center, Library, and Machine Shop), contacts with the Atlanta business community, aid with marketing of products, introductions to possible sources of financing, and attractive on-campus space. For qualified companies, the ATDC operates an 83,000-square-foot Technology Business Center on the northern edge of campus. This building offers, in addition to attractive office space, high-bay areas suitable for small-scale production and laboratory activities.

Georgia Tech Education Extension

Georgia Tech Education Extension serves as the Institute's primary educational outreach to both the public and private sectors. It is the Institute's designated unit for noncredit instruction, provided through workshops, conferences, and seminars. Georgia Tech Education Extension maintains the following subunits for conducting specialized programs for specific clients:

Continuing Education. Innovative programs in emerging fields and classic offerings in traditional disciplines mark the wide array of instruction conducted by Continuing Education. This subunit is responsible for offering the majority of Education Extension's general professional development programs.

Computer Institute. Offerings range from introductory to applied computer-related courses available to the public and private sector on a noncredit basis.

Language Institute. Intensive English noncredit courses are available for foreign students. The Language Institute offers classroom instruction in English as a foreign language on six levels, four hours a day, five days a week during each quarter. This intensive program, which began in 1958, treats all skills and includes TOEFL, MELAB, and SAT preparation. Classes are small, and special individual and laboratory sessions are routine. For a descriptive brochure write to Dr. Louis J. Zahn, Director, Language Institute, Education Extension, Georgia Institute of Technology, Atlanta, Georgia 30332-0385, USA.

The Institute of Planning/Operational Analysis. This provides a focal point and catalyst for military education activities.

Video-based Instructional System. Georgia Tech Education Extension also delivers graduate-level courses and degree programs off campus through the Video-based Instructional System. These courses are conducted via videotape. Additionally, Education Extension transmits by communication satellite all the Association for Media-based Continuing Engineering Education (AMCEE) noncredit course offerings throughout the United States. Certain credit courses offered by the National Technological University are also uplinked by Education Extension from the Georgia Tech campus.

Education Extension uses Georgia Tech's faculty resources in the areas of teaching and research to furnish local, state, regional, national, and international communities with updated information on new ideas, issues

technologies, and developments. Georgia Tech Education Extension cooperates closely with business, industry, government, trade associations, and professional organizations in planning and presenting these special educational programs. Programs are conducted on the Georgia Tech campus or at public meeting facilities, hotels, or company sites. Length of the programs varies according to client needs.

Industrial Education

The Industrial Education department provides in-plant or on-site training activities to business and industry; develops specialized programs in technology; offers seminars, conferences, workshops, and other activities; and conducts programs in safety, productivity improvement, instruction techniques, supervision, statistical control, and a multitude of additional subject areas. In cooperation with the Georgia Department of Education, it develops and conducts specialized training activities for Georgia's textile industry. The department serves the training and educational needs of industries and businesses in Georgia.

Oak Ridge Associated Universities

Georgia Tech is one of the sponsors of Oak Ridge Associated Universities (ORAU), a nonprofit education and research management corporation of fifty colleges and universities. Concentrating on energy, health, and the environment, ORAU conducts programs of research, education, information, and human resource development for a variety of government and private organizations.

ORAU's competitive research programs enable undergraduates, graduate students, and faculty members to work on problems at the research facilities of the United States Department of Energy. Participants are selected by ORAU in cooperation with the staff of each facility.

For more information, contact Dr. Gary W. Poehlein, associate vice-president for Graduate Studies and Research and Georgia Tech ORAU representative.

Skidaway Institute of Oceanography

Located on Skidaway Island near Savannah, the Skidaway Institute provides a complex of coastal- and marine-related educational and research opportunities. Members of the Tech faculty and their students can either participate in established research activities or initiate research compatible with the facility's purpose.

The Institute maintains small boats, a forty-foot research vessel for near-shore work, and the R/V *Blue Fin*, a seventy-two-foot vessel for research at distances up to one hundred miles offshore. Areas of research expertise at the Institute include chemical oceanography, physical oceanography, biological oceanography, and marine geology.

Interdisciplinary Programs

The Office of Interdisciplinary Programs coordinates interdisciplinary research centers at Georgia Tech. The office currently provides administrative coordination for twenty-one units—the Center for Architectural Conservation, the Bioengineering Center, the Research Center for Biotechnology, the Communication Research Center, the Computational Mechanics Center, the Construction Research Center, the Emory-Georgia Tech Biomedical Technology Research Center, the Environmental Resources Center, the Fracture and Fatigue Research Laboratory, The Fusion Research Center, the Georgia Mining and Mineral Resources Institute, the Georgia Productivity Center, the Health Systems Research Center, the Materials Handling Research Center, the Microelectronics Research Center, the Nuclear Research Center, the Rehabilitation Technology Center, the Center for Excellence in Rotary Wing Aircraft Technology, the Software Engineering Research Center, the Technology Policy and Assessment Center, and the Center on Work Performance Problems. While the centers offer no designated degrees, center staff members teach courses in other departments and schools of the Institute, assist in the development of interdisciplinary curricula, conduct various research projects, engage in public service programs, and coordinate appropriate interdisciplinary activities.

The Center for Architectural Conservation focuses on research in the technology of existing buildings to promote, enhance, and assist in the conservation and re-use of the built environment.

The Bioengineering Center emphasizes application of the knowledge, techniques, and approaches of engineering, the physical sciences, engineering, social sciences, and management to the solution of problems arising in medicine and biology. The Bioengineering Center is the principal focus for program leadership in this area. The Center coordinates on-campus bioengineering research, aids investigators in developing collaborative programs with other institutions, and provides a technical interface for off-campus organizations interested in Georgia Tech bioengineering activities. In addition to a research emphasis, the Bioengineering Center works closely with the Multidisciplinary Committee for Bioengineering to promote academic programs of study.

The Research Center for Biotechnology coordinates the Institute's educational and research programs that deal with biotechnology, including microbiology, genetic engineering, biochemistry, biophysics, chemical and biochemical engineering, and biomass utilization. This multidisciplinary approach provides students and faculty with extended opportunities for developing the complex procedures required for the biological production of valuable products.

The Communication Research Center collaborates with specialists in academic fields and with corporate managers in developing their capacities to formulate information in both speech and writing. The Center's basic research in composition and discourse processing enables solutions to practical problems of communication in both business and academic settings—problems in document design, information management, software documentation, and training procedures.

The Emory-Georgia Tech Biomedical Technology Research Center was established by Georgia Tech and the Emory University Medical School in Atlanta to provide an environment in which collaborative research and education in the medical biological, engineering, and physical sciences can flourish and through which advances in research can be transferred to the delivery of health care. The Biomedical Technology Research Center provides support for promising research projects involving Emory and Georgia Tech co-investigators, and it administers an M.D./ Ph.D. program in which students can receive an M.D. degree from the Emory Medical School and a Ph.D. degree from Georgia Tech.

The Computational Mechanics Center is dedicated to the advancement of the science of computational analyses. Major research thrusts include nonlinear and dynamic fracture mechanics, failure analysis, advanced stress and durability studies, hot section jet engine technology, fatigue analysis, and advanced computational techniques for manufacturing processes.

The Environmental Resources Center coordinates applications of Tech's expertise in science and technology to address problems of managing environmental resources. It organizes and administers water resources research projects at colleges throughout Georgia and disseminates their results.

The Fracture and Fatigue Research Lab encourages interdisciplinary research and educational opportunities at Georgia Tech in the field of fracture and fatigue of materials. The research programs encompass the behavior of a wide range of materials, including metals, ceramics, polymers, and composites. There is a strong emphasis on high-temperature materials used in the aerospace industry as well as on materials used in the ground vehicle and electric power industries.

For more information, see page 145 of this catalog.

The Fusion Research Center integrates and focuses faculty research interests in the various areas of physics and technology related to fusion research and development. Research is presently conducted in applied plasma theory, plasma diagnostics, surface materials-plasma interaction, electromagnetics, and fusion reactor conceptual design.

The Georgia Mining and Mineral Resources Institute provides the specialized training in mineral engineering education and research that is necessary to meet the growing technology needs of modern mineral and fuel industries. The programs are essentially multidisciplinary, involving effective use of the wide range of appropriate expertise and facilities that exist throughout the College of Engineering; a Mineral Engineering Certificate may be earned at the bachelor's, master's, or doctoral level. Since the products of the mineral industry—metals, minerals, and energy—are crucial to the United States economy and national security, there is now national recognition of the vital need for accelerated growth of our mineral engineering technology as domestic ore grade inevitably decreases.

The Georgia Productivity Center encourages productivity improvement in Georgia's industries through the application of research, development, and technology transfer. The Center carries out economic analyses to identify factors that affect productivity and performs research projects in various engineering and science disciplines to solve productivity problems. The research results are made available and are transferred through direct assistance offered by Tech's twelve field offices throughout the state in demonstration projects, short courses, and in-plant seminars. Some of the areas to which technology has been applied to improve productivity include reduction of material wastes, energy conservation, introduction of computers, improved plant layouts and manufacturing processes, equipment modernization, and improved work practices.

The Health Systems Research Center provides an interdisciplinary and interinstitutional program of health systems research, community outreach, and continuing education. The Center develops, applies, and disseminates new knowledge and techniques in all aspects of improved operational and managerial systems for the delivery of health care to the public. The Center emphasizes systematic planning, engineering design, and scientific management of health care facilities, work methods, and human resources.
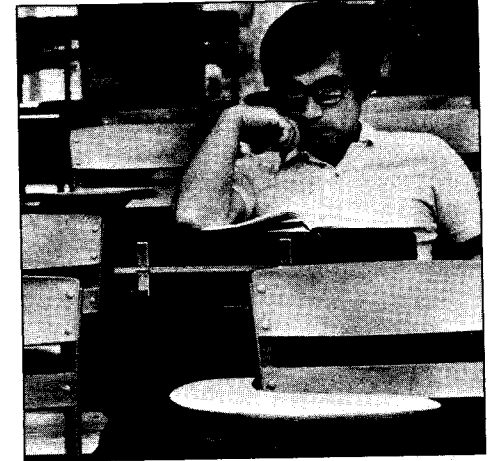
The Material Handling Research Center is an industry/university cooperative research center sponsored by United States corporations, Georgia Tech, and the National Science Foundation. In response to the research needs of its member companies, the Center performs interdisciplinary research in areas such as manufacturing systems, flexible automation, intelligent systems, and warehousing/logistics systems. The member companies participate in establishing the research agenda for the Center; they also receive the benefits of the research in advance of any general dissemination.

The Georgia Tech Microelectronics Research Center provides a mechanism for the formal coordination of campus programs of a microelectronics nature conducted within existing campus organizational units. The Center also provides a focus for the development of specialized facilities used in support of interdisciplinary research activities. Typical research programs encompass semiconductor materials growth and characterization, anisotropic etching, high field-hot electron effects on device modeling, laser annealing, very large scale integration chip design, and semiconductor device and circuit fabrication.

The Nuclear Research Center provides facilities for physical, chemical, and medical research involving neutrons and ionizing radiations. In particular, it provides access for multiple-discipline users to a five-megawatt research reactor and extensive radiochemical, radioanalytical, and radiobiological facilities. Ongoing work includes trace element analysis, production of radioisotopes for medical and industrial use, medical applications research, neutron radiography, industrial radiation exposure tests, and personnel training programs for industry. An additional program supports reactor use by colleges and universities throughout the southeastern United States.

The Rehabilitation Technology Center facilitates research on devices and systems that help handicapped or disabled persons removing functional barriers in the work place, home, and community environments. Collaborative research relationships have been established with the Atlanta Veterans Administration Medical Center, the Division of Rehabilitation Services (Georgia Department of Human Resources), the Roosevelt Warm Springs Institute, and Emory University.

The Center for Excellence in Rotary Wing Aircraft Technology provides a national focal point to stimulate more continuous research in helicopter technology and more comprehensive graduate training for engineers in the field. Georgia Tech was selected by the United States Army as one of their three centers for excellence in rotary wing aircraft technology.

The Software Engineering Research Center (SERC) is a multidisciplinary research center, centrally managed and dedicated to research, development, and technology transition in the technologies that aid in the efficient production of low-cost, high-quality computer software for a variety of applications.

As the newest of the twenty-one research centers on the Georgia Tech campus, SERC is a focal point of excellence for research and development in methodologies, tools, and technologies that provide order-of-magnitude increases in capabilities to produce quality software. By combining a critical mass of researchers and advanced technological capabilities, SERC also demonstrates and packages software engineering products and services for distribution to a network of subscribers and sponsors.

The SERC technical staff is composed of research and academic faculty members from the university's departments and colleges. Since the SERC is an integral part of the Georgia Tech community, center members and subscribers have access to the extensive research facilities that Georgia Tech offers.

The Technology Policy and Assessment Center brings together faculty and student research teams to conduct research on major technology policy issues that face our society. Typical areas of investigation involve analyses of social impact, organizational behavior, institutional responsiveness, and cost-risk-benefit features associated with alternative policies and strategies for the management of scientific and technological developments.

The Center for Work Performance Problems promotes and conducts research, education, and consultation on the broad range of workplace issues that relate to the human side of work performance. These issues encompass both those problems employees bring to work and those created by the work environment. The aim of the Center is to serve as a resource to participating employers and labor organizations to reduce the negative impact of these problems. The Center is housed in the College of Management.

Student Life

The vice-president/dean of Student Affairs and his staff coordinate and administer extracurricular student services and activities. For complete information concerning these services, see the *Guide to Student Life,* available to all students from the Division of Student Affairs.

Community Services

Georgia Tech applies its resources through community services to the needs of the community and provides an outlet for creative individual response to social problems.

Counseling and Career Planning Center

Students encountering almost any difficulty may find help at the Counseling Center. Professional counselors assist in a completely confidential manner with academic, career, and personal difficulties whenever students request their services. The Center also provides information on careers; job search; resume writing; other colleges; admission to law, business, and graduate schools; and a number of tests for determining interests, abilities, and personality traits.

Fraternities and Sororities

The Fraternity Affairs and Women's Programs offices coordinate and administer the many activities and programs of the thirty-one social fraternities and seven sororities on the Tech campus.

Student Publications and Radio

The student publications and radio communications boards oversee the budgeting and operation of the *Technique*, the official student newspaper; the *Blueprint*, the student yearbook; and other publications, in addition to the operation of the student FM radio station, WREK.

Women's Programs

Students' services and programs aim toward involving female students in all phases of campus life and providing resources to fulfill the Institute's intention of accepting all qualified female students who apply.

Housing Office

The Housing Office supervises the assignment of rooms for 4,200 single students and 298 married students. A residence hall program provides counseling services and organized activities for residence hall and family housing residents. For further information, refer to the residence hall and/or family housing brochures available at the Housing Office.

Student Health Center

The Student Health Center is a modern ambulatory care center with a medical laboratory, a pharmacy, beds for thirty patients, and facilities for out-patient treatment, X-ray examinations, and physical therapy.

The staff consists of six full-time physicians, visiting consultants in psychiatry and radiology, a pharmacist, registered nurses, physician assistants, and laboratory and X-ray technologists. The full-time physicians have training in family practice, internal medicine, surgery, gynecology, sports medicine, pulmonary medicine, and emergency medicine. Physicians and dentists on the consulting staff represent all medical and dental specialties; their services are available on a fee-for-service basis. Funds for operating the Health Center are derived solely from the student health fee.

Since the facilities of the Student Health Center are limited, supplemental insurance to cover major illnesses, major surgery, specialist consultations, and sophisticated diagnostic procedures should be purchased by all students who are not included in their parents' or spouse's medical insurance plans. Local hospitals, as a rule, will not admit any patient who does not have hospitalization.

International Students

Over nine hundred international students from eighty countries choose Georgia Tech for their educational advancement. The Department of International Student Services and Programs (DISSP) assists these students in adjusting to Georgia Tech and to life in America. In return, many of the students work with the DISSP staff to develop programs promoting intracultural understanding.

New Student/Parent Programs (FASET)

The student/parent orientation program informs new students and their parents of academic programs and requirements, in addition to familiarizing them with Tech traditions and the activities and services available on campus.

Minority Educational Development

The Office of Minority Educational Development sponsors a variety of programs to assist minority students in adjusting to Georgia Tech. A rigorous precollege academic program, CHALLENGE, seeks to acclimate students to the pace of scholastic life, while supplemental orientation programs and tutorial and peer counseling services are available to students once they have enrolled.

Placement Service

The Office of Corporate Relations and Placement is located in the Fred W. Ajax Placement Center on Hemphill Avenue. The office offers the Georgia Tech community a variety of services, including opportunities for full-time employment as well as part-time, temporary, and summer employment. One of the primary objectives of the Office is to assist students in determining career objectives and in attaining employment goals.

The Office of Corporate Relations and Placement maintains a library that includes information on specific employers, governmental services, and special publications related to employment. In addition, the Office keeps local and national salary data, employment patterns of Georgia Tech graduates (employers, types of positions, and work locations), and graduate and professional school information.

Other services of the Office of Corporate Relations and Placement include seminars the employment process, resume preparation effective interviewing techniques, and letter writing campaigns. In addition, the Office issues a resume book, as well as maintains an open resume file for employer review. Annually, over seven hundred employers, representing a substantial number of the Fortune 500 corporations, interact directly with the Office.

The Office also provides assistance to corporate university relations officials in the planning, implementation, and administration of effective corporate-university relation programs, in addition to stimulating and encouraging corporate support through financial grants, fellowships, scholarships, faculty support, and equipment.

Student Center

The staff of the Fred B. Wenn Student Center plans and coordinates programs and activities for students, staff, faculty, alumni, and their guests. As the vigorous heart of the campus, the Center has post office, recreational, exhibit, and hobby facilities available to serve the diverse interests of Tech's student and faculty/staff population.

Student Government

The Georgia Tech Student Government Association and the Graduate Student Senate enable students to maintain responsible and respected self-government in academic and nonacademic affairs.

Health Information

Students will receive a Health Information and Physical Examination Form with the notice of their acceptance for enrollment. The prospective student should complete the form and mail it to the director of Student Health Service well before the date of initial registration. *All sections of the Health and Physical Examination Form must be completed; otherwise, registration will be delayed.* Students should follow the instructions on the health form explicitly and also fill out the summary sheet on the last page. Tuberculosis screening and immunizations as listed on the health form are required of students. The Physical Examination Section should be completed by the student's family physician.

It is the responsibility of all students to notify the director of Student Health Service and the Physical Education Department of any disability or handicap that would make participation in swimming, competitive sports, and aerobic training hazardous to their well being. Any student requesting special consideration because of mental or physical disability should have his or her physician write an explanatory letter to the director of Student Health Service, giving full details of the disability and any desired limitations on physical activity. This letter must accompany the health information record. If students want to continue allergy shots or treatments that have been started by their physician, they should enclose a detailed signed instruction sheet from their physician.

All students from the United States and all international students from Australia, Canada, Denmark, England, Ireland, Netherlands, New Zealand, Northern Ireland, Norway, and Sweden must have a skin test for tuberculosis. This skin test must be current and will not be accepted if it was performed more than six months prior to registration. If the skin test is positive, a negative chest X-ray report signed by a licensed physician and taken no more than six months prior to registration must be enclosed. Skin tests and X-rays are performed at most local health departments in the United States at a minimal cost. *If the above procedure is not followed, the student will not be permitted to register.*

All international students from areas and countries not mentioned above must have a skin test and/or chest X-ray prior to clearance for registration. **This skin test and/or chest X-ray must be taken at the Georgia Tech Health Center prior to the date of registration.** The cost of these procedures will be borne by the student. These tests will be performed at the Health Center the week prior to registration for the spring, summer, and fall quarters. For the winter quarter, they will be done during registration. Since these tests may take five to six days, students should report to the Health Center as early as possible so that registration will not be delayed.

If the X-ray is abnormal and suspicious of tuberculosis, the student will be referred for diagnosis and treatment. The student may return to classes when the possibility of disseminating tuberculosis is no longer present. *If the student does not comply with the above, he or she will not be permitted to register for classes.*

In accordance with the recommendations and guidelines of the United States Public Health Service, all students with AIDS, with ARC (AIDS-related Complex), or with a positive HTLV-III antibody test are directed to report this fact to the director of Student Health Service as soon as they arrive on campus. Confidentiality will be maintained. Counseling and support for these students will be available.

Completed health forms and inquiries should be mailed to:

Director of Student Health Service
Georgia Tech Student Health Center
275 Fifth Street, NW
Atlanta, GA 30318

Assistance for the Handicapped

Georgia Tech's committee for handicapped assistance and planning ensures compliance with federal law and works to provide a serviceable environment.

Handicapped persons with access problems to buildings and parking should contact the director of campus safety at 894-4588. If you know of any handicapped persons in need of assistance, please notify the equal opportunity/affirmative action officer, the dean of students, or the director of Campus Safety.

Georgia Tech currently provides the following services for handicapped students: special orientation; wheelchairs for use on campus; reserved parking spaces; reader services for the visually impaired; assistance in securing the services of interpreters for individuals with hearing impairments; aid in registering for classes; assistance from Safety and Security personnel; special assistance from the Student Health Center; and help in securing housing. Tech also allows some students to waive certain course requirements, such as field trips. Students should discuss this option with their academic adviser.

For more information concerning the handicapped, contact John Gibson at 894-2499, Annette Cummings at 894-3249 (Faculty/Staff), or Juanita Lloyd (Students) at 894-2560.
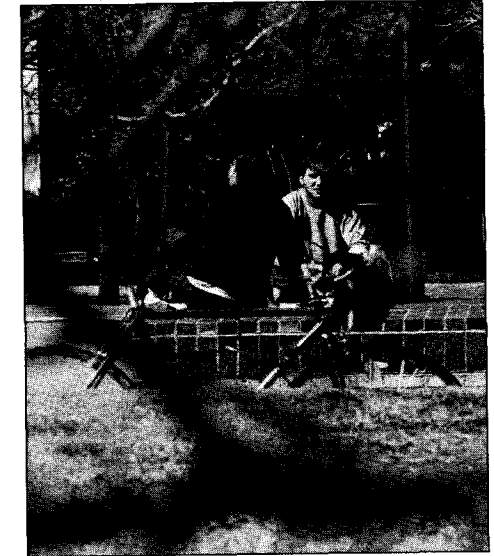
Annual Notice of Privacy Rights

This institution observes the Family Educational Rights and Privacy Act of 1974 (FERPA), designed to protect student rights with regard to educational records maintained by the institution. Under this Act, students have the following rights: (1) the right to inspect and review educational records maintained by the institution that pertain to them; (2) the right to challenge the content of records on the ground that they are inaccurate, misleading, or a violation of their privacy or other rights; and (3) the right to control disclosures from their educational records with certain exceptions.

A written policy detailing how Georgia Tech will comply with the provisions of the Act is printed in the *Guide to Student Life*, available in the Division of Student Affairs. The registrar has the institutional responsibility for interpreting (a) the Family Educational Rights and Privacy Act of 1974, as amended, (b) rules and regulations issued by the Department of Education, to enforce this Act, and (c) the written policy of the institution.

Students who believe the institution has violated the written policy and/or the provisions of the Family Educational Rights and Privacy Act should send a written complaint to the registrar, specifying the nature of the possible violation. The registrar shall investigate the complaint and initiate corrective action if it appears the institution is in violation. The registrar shall notify the complainant of the results of the review within a reasonable period of time, not to exceed thirty calendar days. Students also have the right to file complaints with the FERPA Office of the Department of Education, Washington, D.C. 20201, regarding alleged violations of the Act.
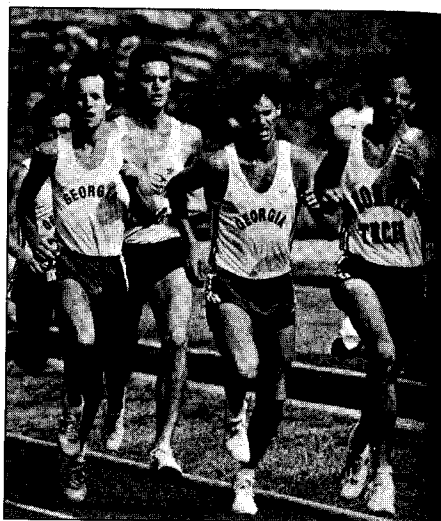
Affiliated Organizations

The Georgia Tech Athletic Association

This not-for-profit corporation administers intercollegiate sports at Georgia Tech through a board of trustees consisting of seven faculty members, three alumni, and three students, with the president of Tech serving as president of the board. The Association aims to secure cooperation of the faculty and students in athletic affairs, to maintain a high standard of sportsmanship, and to provide facilities that allow students to participate in athletic activities. Through the support of the Athletic Association, Georgia Tech promotes intercollegiate playing schedules in football, basketball, cross country, swimming, track, golf, tennis, baseball, gymnastics, wrestling, volleyball, and softball.
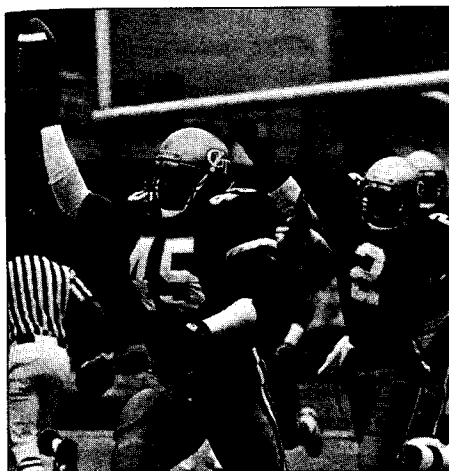
The Georgia Tech Alumni Association

The Georgia Tech Alumni Association was chartered in 1908. It is a not-for-profit organization whose mission is (1) to promote active alumni participation in Georgia Tech events and activities; (2) to promote alumni volunteer support for Tech through the Roll Call, special projects, capital campaigns, and other fund-raising activities; (3) to promote the academic and research achievements of the Institute; (4) to act as liaison between the alumni and the administration of the Institute; and (5) to manage the resources of the Association to achieve its goals in the most cost-effective manner.

As a service organization, the Alumni Association accomplishes its mission by publishing the *Georgia Tech Alumni Magazine* and *Tech Topics*, the alumni newspaper; by organizing and supervising alumni clubs throughout the country and in international locations, and by designing and presenting alumni programs such as homecoming events, reunions, workshops, and seminars. Young alumni are encouraged to become involved in the affairs of the Association and the Institute through participation in campus programs, senior orientation, and the career advisory service for students. The Association also maintains the official alumni statistical records and files to ensure complete and accurate communication with Tech's seventy thousand alumni. Monetary support is provided by alumni and friends through their participation in the annual Roll Call.

The Alumni Association also provides opportunities for employment for both alumni and graduating seniors through its Alumni Placement Service. Since 1936, th office has provided industry, business, and government with an excellent source of we educated, broadly experienced candidates employment.

In addition to publishing the *Alumni Placement Bulletin*, the Association runs a Annual Career Conference and Career Sec tion in *Tech Topics*, which is extremely beneficial for alumni searching for employ ment. The placement office also sponsors seminars on topics related to employment.

Last year, the Alumni Association initia a new program called Wrek Net, an on-lin interactive computerized network that allo alumni with personal computers to tie directly into the Alumni Association to receive information about campus activitie

The Alumni Association offices are located in the L.W. "Chip" Robert, Jr., Alumni/Faculty House on North Avenue; (404) 894-2391.

Georgia Tech Foundation, Inc.

The Georgia Tech Foundation, Inc., is a not-for-profit, tax-exempt corporation that receives, administers, and invests virtually all contributions made in support of the academic programs of the Georgia Institute of Technology. The Board of Trustees of the Georgia Tech Foundation, Inc., maintains its support of the Institute through its thirty-seven members, distinguished by their exper-tise in financial management and investments and by their devotion to the Institute.

The assets of the Foundation exceed $58 million, with an annual income of almost $4 million. Allocation of these funds is made to meet the most pressing needs of the Institute, particularly for faculty profes-sional development and other programs to help maintain a strong instructional staff and curriculum; for undergraduate and graduate student support, both for needy and excep-tionally well-qualified students such as National Merit Scholars; and for research support, including equipment.

The Georgia Tech Research Corporation

The Georgia Tech Research Corporation is a not-for-profit organization that seeks and administers funds for research activity in all administrative divisions of Georgia Tech. It is the coordinating agency for patent applica-tions and other matters related to the protection and use of technological discov-eries made at Georgia Tech.
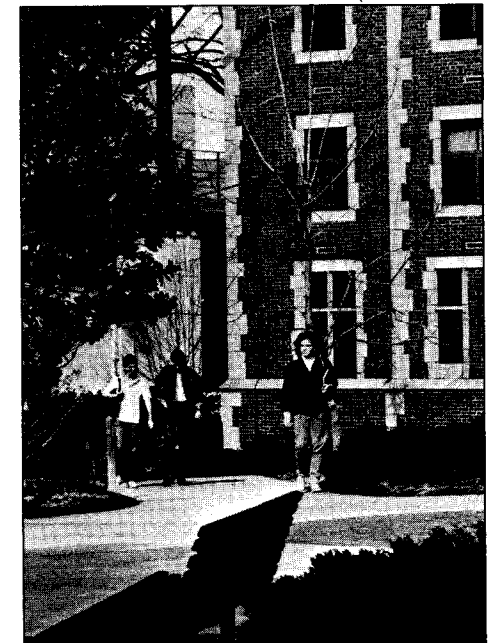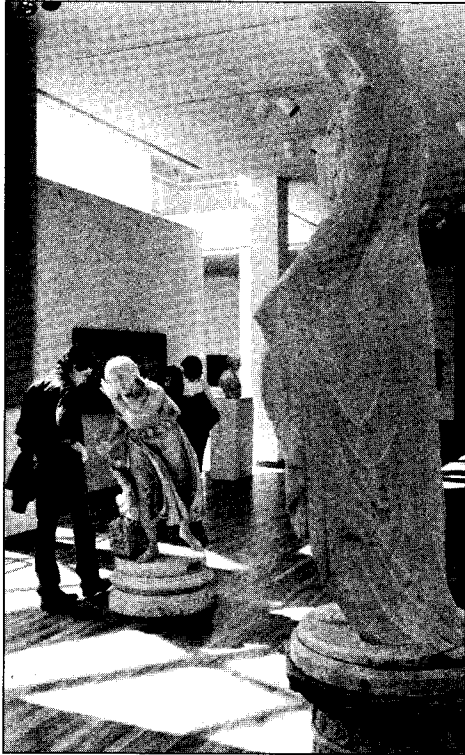
High Museum of Art

Atlanta

Georgia Tech is located in Atlanta, listed in the *Places Rated Almanac* as one of the most livable cities in the nation. As the capital of Georgia, Atlanta is home to more than two million residents and many of the nation's most prominent business, financial and industrial firms. Its geographic location has made it the transportation center of the Southeast, as demonstrated by the success of the Hartsfield International Airport, generally considered the nation's largest and second busiest air terminal. At 1,050 feet above sea level, the city, famous for tree-lined streets and beautiful gardens, enjoys a pleasant climate permitting year-round outdoor activities. One of the best public transportation systems in North America contribute to Atlanta's appeal.
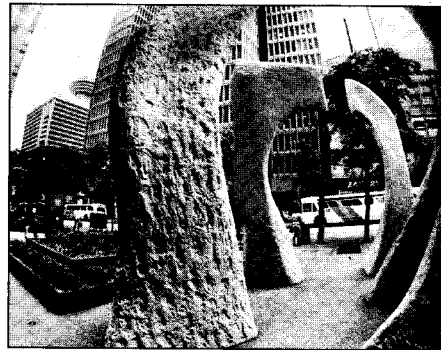
Peachtree Center in downtown Atlanta

Atlanta is also a vigorous city offering an impressive variety of entertainment ranging from sporting events to symphony and theatrical performances. In response to the city's increasing artistic sophistication, Atlanta provides experimental theatre, diverse musical events, a thriving film industry, and a respected art museum. Each year, the city sponsors a week-long arts festival in Piedmont Park, two miles from the Georgia Tech campus. The historic Fox Theatre hosts varied cultural and popular performances, including ballet, jazz, opera, country, Broadway musicals, and rock concerts. The Braves, Hawks, and Falcons offer quality professional baseball, basketball, and football action for Atlanta spectators. Nearby lakes and mountains offer water sports, camping, and snow skiing for those who prefer more energetic activities. Also popular are attractions such as Six Flags Over Georgia, the Cyclorama at Grant Park, and Stone Mountain Park.
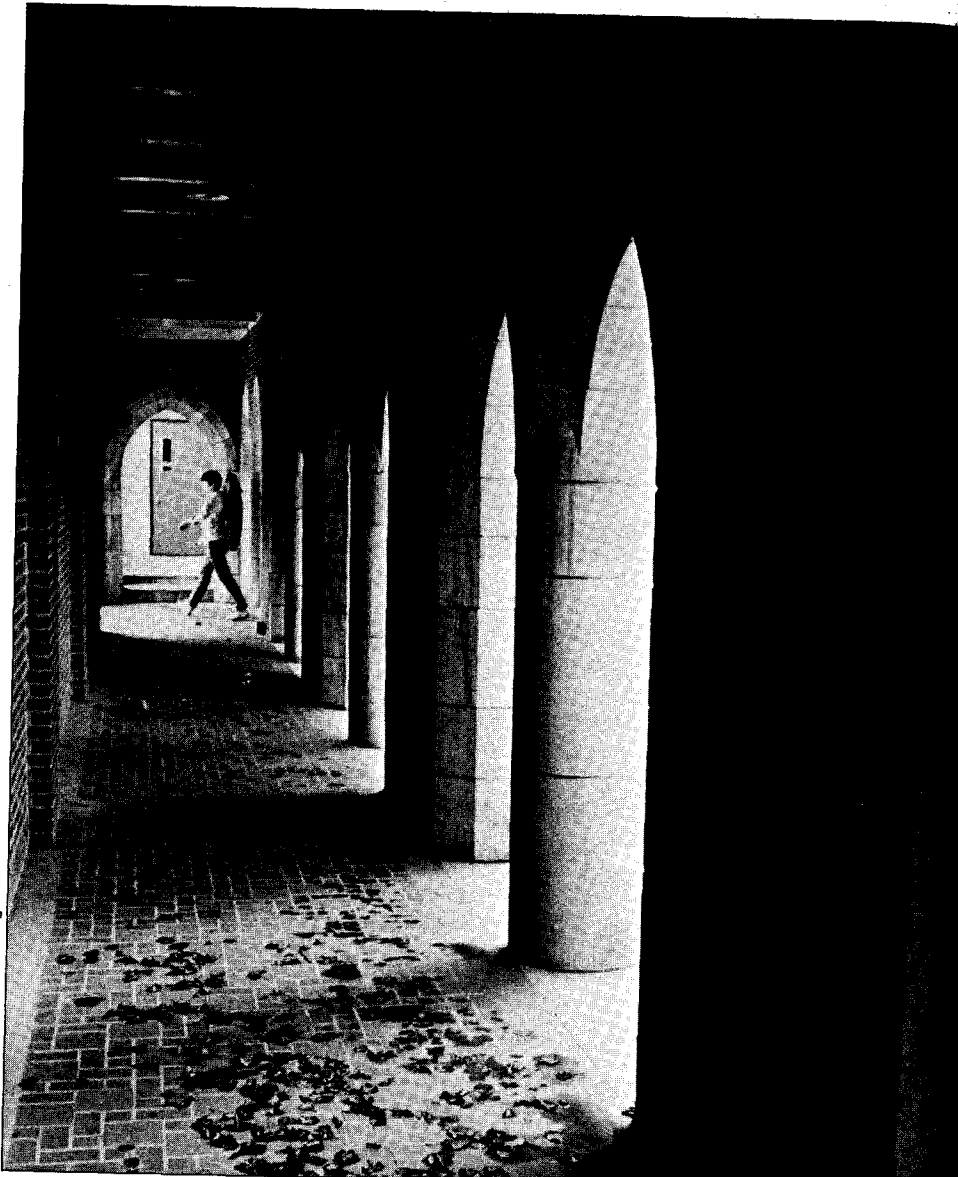
Degrees

The Georgia Institute of Technology at present offers curricula leading to the following undergraduate degrees:

Bachelor of Aerospace Engineering
Bachelor of Ceramic Engineering
Bachelor of Chemical Engineering
Bachelor of Civil Engineering
Bachelor of Computer Engineering
Bachelor of Electrical Engineering
Bachelor of Engineering Science and
 Mechanics
Bachelor of Industrial Engineering
Bachelor of Mechanical Engineering
Bachelor of Nuclear Engineering
Bachelor of Textile Engineering
Bachelor of Science
Bachelor of Science in Applied Biology
Bachelor of Science in Applied Mathematics
Bachelor of Science in Applied Physics
Bachelor of Science in Applied Psychology
Bachelor of Science in Building
 Construction
Bachelor of Science in Chemistry
Bachelor of Science in Economics
Bachelor of Science in Health Physics
Bachelor of Science in Information and
 Computer Science
Bachelor of Science in Industrial Design
Bachelor of Science in Management
Bachelor of Science in Management Science
Bachelor of Science in Physics
Bachelor of Science in Textile Chemistry
Bachelor of Science in Textiles

Graduates who have completed their courses through the Cooperative Division receive the degree with the designation "Cooperative Plan."

Requirements for each degree are listed in "Curricula and Courses of Instruction" under the school responsible for the program. Students should select a degree program as early as possible, preferably with their request for admission, but may postpone the decision until a time as late as the end of the freshman year. Students who have selected a degree program receive academic advisement from the appropriate school; undecided students are advised through the offices of the deans of the four colleges.

Special Programs

The Cooperative Plan

Since 1912, Tech has offered two plans of study—the standard four-year plan and a five-year cooperative plan for students who wish to combine practical experience with technical theory.

Approximately 2,500 cooperative students, selected from applicants on the basis of high scholarship, work in about four hundred industries throughout the country while they complete academic degree programs.

The cooperative division offers programs for majors in aerospace, ceramic, chemical, civil, computer, electrical, industrial and systems, mechanical, nuclear, and textile engineering (including textiles and textile chemistry), and in applied biology, chemistry, engineering science and mechanics, information and computer science, mathematics, physics, and management. The

academic curricula are identical to those offered regular four-year students.

The plan's alternating college and industrial quarters divide students into two sections, the first registering in June and the second in September. The co-ops of section one and those of section two alternate between industry and college, exchanging places with each other every three months for four years. At the beginning of the fifth year, the two sections merge and remain at college together until graduation in June, when each cooperative student receives a bachelor's degree, cooperative plan, in the student's particular field.

The cooperative program offers the student practical experience and insight into human relations, as well as financial assistance. The work experience co-op students receive is a valuable asset to young graduates starting out in their chosen professions. Neither college laboratory experience nor employment during vacations can take the place of organized co-op training in industry. The plan provides, to a substantial degree, the experience most companies require of their employees before promoting them to positions of responsibility. Work experience may also assist students undecided about their future plans in determining early in their college careers whether they wish to continue the study of engineering, science, or management as a life profession.

Moreover, daily contact with diverse groups among their fellow employees offers students practical insight into sociology, psychology, economics, and ethics that no textbook can supply. Finally, students receive compensation for their services from the firms that employ them. Although students are not able to earn all of their college expenses, as a rule they can earn more than half.

Students interested in applying for admission to the cooperative plan should write to the Director, Cooperative Division, Georgia Tech, Atlanta, Georgia 30332-0260, for the division's bulletin, which gives such information as fees, living expenses, and wages paid students while at work.

Multidisciplinary and Certificate Programs

Multidisciplinary Programs in the College of Engineering and Certificate Programs in the College of Management and the College of Sciences and Liberal Studies offer students in good standing an opportunity to broaden their areas of expertise or acquire skills or information beyond their major degree requirements. Students interested in pursuing these programs should consult with their major school adviser.

For a description of Multidisciplinary and Certificate Programs offered in the College of Engineering, see page 82. For a description of similar programs in the College of Sciences and Liberal Studies, see pages 199-200. For information on certificate programs in the College of Management, see pages 181-182.

ROTC

Georgia Tech offers three entirely voluntary ROTC programs that accept both men and women: Army, Navy, and Air Force.

Students may apply six hours of basic ROTC and nine hours of advanced ROTC as elective credit toward a degree. After earning a baccalaureate or graduate degree and completing the advanced ROTC courses for any of the three services, a student may receive a commission in either the reserve or regular forces.

Each ROTC unit offers scholarship programs of two, three, and four years. All juniors and seniors selected for the advanced courses receive a substantial monetary allowance each month while enrolled in ROTC.

Dual Degree Program

To assist the many high school students seeking an educational experience combining a typical liberal arts program with a technological curriculum, Georgia Tech offers the Dual Degree Program. Under this plan, the student attends a liberal arts college for three years, then comes to Tech for approximately two years. Upon completion of the program, the student receives a bachelor's degree from the liberal arts college and a bachelor's degree from Georgia Tech.

Programs of study at Tech may concentrate in any of the various specialty areas of engineering, science, mathematics, or management. The list of colleges participating in the Dual Degree Program incorporates several units of the University System of Georgia, the Atlanta University Center Colleges, and approximately fifty other colleges and universities throughout the nation, including ten traditionally black colleges and many predominantly women's colleges. Because of their classification as transfer students, Dual Degree Program applicants must meet all requirements for transfer.

Preprofessional Programs

Georgia Tech's philosophy with respect to preparation for medical, dental, and law school involves preparing students for entrance into the chosen professional school while simultaneously building the educational background for an alternate career. This approach provides each student with a more individualized program and a broader range of options than traditional programs.

In keeping with this philosophy, there are no majors at Georgia Tech designated as premedicine, predentistry, or prelaw. Students pursuing these programs use the elective hours within any major of their choice to take the additional courses required for entrance to medical, dental, or law schools.

This approach to preprofessional education has two major advantages. First, students who do not enter professional school upon graduation, as expected, are prepared to undertake a rewarding alternate career immediately. Second, students who continue into professional school can graduate with backgrounds that uniquely qualify them for desirable careers with special emphases; for example, medical research related to artificial organs or the legal aspects of design and construction.

Most successful applicants to medical and dental schools have a broad education in the humanities and social sciences, with particular competence in the natural sciences. Within those guidelines, no specific undergraduate majors have a clear competitive advantage in assuring admission. Therefore, since students whose academic records demonstrate a high level of ability are most likely to gain admission, the best choice of undergraduate major for an individual student is usually the field in which he or she has the greatest inherent interest.

Bachelor's degree programs frequently chosen by premedical and predental students are applied biology, chemistry, psychology, and the undesignated Bachelor of Science. Programs chosen frequently by prelaw students are engineering, management, and psychology.

Most major schools have preprofessional advisers to assist students in choosing electives to build the appropriate background for their professional interests. Also, the Institute has a chief premedical adviser. Every premedical, predental, and prelaw student should consult early with the preprofessional adviser in his or her major area to plan an appropriate program of elective courses.

Preparation for Careers in High School Teaching

Georgia Institute of Technology and Georgia State University participate in a cooperative program designed to produce high school science and mathematics teachers with Georgia Tech's expertise in technical subjects and Georgia State's expertise in professional education. In this program, Georgia Tech students use elective hours to take the required professional education courses at Georgia State. Thus, they simultaneously satisfy the requirements for a Tech degree and the teaching certification at the high school level.

This option is available in applied biology, chemistry, mathematics, physics, and psychology. Students pursuing it should consult the appropriate adviser in their major school for help in structuring a program of electives that includes the required professional education courses. This structuring must be done early in the student's academic program to accommodate all requirements.

Joint Enrollment Program for High School Students (JEPHS)

Georgia Tech admits a limited number of gifted students who have completed the

eleventh grade with academic credentials comparable to those of scholastically superior freshmen at Tech.

Students admitted in this category may take part or all of their course work at Tech, including the subject areas needed to fulfill high school graduation requirements. The student receives high school credit for the Tech courses and actually graduates with his or her high school class. Additionally, all work taken at Georgia Tech counts toward an Institute degree if it is part of a particular curriculum taken by the student at a later date.

To be eligible to participate in this program, the local school system must sign the appropriate agreement with the Georgia Institute of Technology. Students should check with local school officials to determine if their particular system is a participating member. If so, the student should discuss with the high school counselor specific course, test, and recommendation requirements for JEPHS. For further information or assistance, contact the admissions office at Georgia Tech.

Special Academic Services

In an effort to assist its students in realizing their full intellectual potential, Georgia Tech sponsors a variety of voluntary programs designed to help the student overcome academic problems.

The mathematics department laboratory, open Monday through Friday afternoons while classes are in session, offers a tutoring service for any Tech student in a freshman-level mathematics course. Students who fail the Regents' Examination in composition, required for graduation, may take a special course to improve their skills. International students may take courses in language and literature designed to introduce nonnative speakers to written and spoken English as well as to American customs, ideas, and literature.

The STEP program, coordinated through the Office of the Dean of Engineering, provides help with freshman mathematics and science courses. Students may receive quick answers to telephoned questions on current assignments, attend short personal

tutoring sessions, and participate in occasional group coaching in particularly troublesome areas.

PREP Program

The College of Sciences and Liberal Studies offers college preparatory courses in reading, mathematics, and English composition for students who need further preparation before taking credited courses in English, mathematics, and history.

Students who are required by the Institute to take courses in the PREP Program will be notified in writing. They must then either test out of the program or register for the required courses before they can register for any credit courses for which the required PREP courses are prerequisite.

Students can test out of taking PREP courses by passing Basic Skills Exams administered during FASET through the Office of the Dean of COSALS. Students who do not pass the appropriate examinations prior to their first quarter in residence must register for the required PREP courses. Students must pass all required PREP courses and Basic Skills Examinations within their first four quarters in residence in order to register for any further course work.

In addition to those students who are required by the Institute to take PREP courses, any student who wishes further preparation may register for one or more of them. PREP courses are not prerequisite to credit courses when taken on this elective basis.

PREP courses are offered on a pass/fail basis and may not be counted as hours toward graduation.

PREP 0015. Reading Skills
5-0-5.
Development of reading comprehension and speed, vocabulary, and study skills. Review of grammar and usage. Offered fall and as needed.

PREP 0020. Mathematics Skills
5-0-5.
Intensive review of arithmetic and algebraic skills. Development of mathematics study skills. Offered fall and as needed.

PREP 0025. English Skills
5-0-5.
Development of basic skills used in writing the sentence, paragraph, and short essay. Development of reading speed. Offered winter and as needed.

FL 0031. English as a Foreign Language
5-0-5.
Review of basic oral, aural, reading, and writing skills.

Admissions

Both freshman and transfer students may enter Tech in any of the four academic quarters, which begin in September, January, March, and June.

Freshman student deadlines for submission of the Application for Admission, the $15 application fee, and all required credentials are as follows:

Quarter	Deadline
Summer	February 1
Fall	February 1
Winter	October 1
Spring	January 1

Transfer student deadlines for submission of the Application for Admission, application fee, and all required credentials are as follows:

Quarter	Deadline
Summer	April 1*
Fall	June 1*
Winter	October 1
Spring	January 1

*February 1 for students seeking financial aid.

The Office of Admissions will consider all applications on file by the stated deadlines provided spaces are available for the particular quarter or academic year for which the student applies. An application submitted after the deadline may receive consideration, but only at the discretion of the Institute.

Transfer students should plan their transfer so as to allow ample time for their previous school to send transcripts to Georgia Tech. If Tech does not receive official final transcripts prior to the last day of registration, the Office of Admissions will not allow the student seeking transfer to complete registration.

The *Guide to Undergraduate Admissions*, designed to assist applicants until their enrollment at Tech, details policies and

procedures concerning areas such as admissions requirements, acceptance notification, housing application, financial aid, cooperative plan, joint enrollment, dual degree program, and early admissions. Applicants may obtain this publication from the Office of Admissions.

For any information regarding admission to Georgia Tech, write to
Director of Admissions
Georgia Institute of Technology
Atlanta, Georgia 30332-0320

Admission of International Students

International students who wish to enroll at Georgia Tech should write to the Office of Admissions for a special information pamphlet describing application procedures and other basic information for applicants from foreign countries. Under most circumstances, international students may enter only in fall quarter.

Advanced Placement and Honors Program

Superior students entering Georgia Tech may receive college credit for courses completed in high school if their scores on the college board Advanced Placement examinations indicate a satisfactory knowledge of college course work. The Departments of English and Foreign Language and the Schools of Applied Biology, Chemistry, Mathematics, Physics, and Social Sciences participate in the voluntary program by offering both advanced placement and course credit. Minimum AP scores of 3 in mathematics or history, 4 in English, French, German, Spanish, chemistry, or physics, and 5 in biology are necessary for consideration in the advanced placement program.

Advanced placement in chemistry is also possible on the basis of high scores on the college board Achievement Tests. With sufficiently high scores on the SAT verbal and the English Achievement Test, students may take an essay test administered by the Department of English. Students who pass the test receive credit for English 1001-2 upon successful completion of a Department literature course with a grade of B or above.

Under certain conditions, the Department of Modern Languages grants up to twelve hours of credit for high school language study. For more information, see page 243 in this catalog.

Veterans Program

Because the Veterans Administration must receive certification of enrollment before issuing benefit payments, any student planning to enroll under any of the VA programs should initiate the certification procedure through the Georgia Tech financial aid office as early as possible, preferably thirty days before entering the Institute. Veterans should bring to the office proof of discharge (DD-214) or, if previously certified, their VA claim number. Failure to request certification thirty days before registration will result in a four- to six-week delay in the receipt of the first benefit check. For further information about the certification procedure, contact the Office of Scholarships and Financial Aid, located on the ground floor of the Administration Building on the Georgia Tech campus.

Veterans must apply to Georgia Tech through the usual admissions procedure. Eligibility for VA benefits does not guarantee acceptance to the institution, nor does acceptance to Tech signify eligibility. The institution serves only as a source of certification and information to the Veterans Administration; the student must carry out all financial transactions with the Veterans Administration directly.

In general, most veterans who served on active duty for more than 180 days, any part of which occurred after January 31, 1955, and before January 1, 1977, are eligible for support to attend college.

Also eligible are sons and daughters between eighteen and twenty-six years old of deceased veterans, of living veterans who have disabilities considered total and permanent, and of veterans whose death or disability was a result of service in the armed forces. Applicants in these catagories should ask their local Veterans Administration office for complete details.

The local Atlanta Veterans Administration address is 730 Peachtree Street, Atlanta, Georgia 30365.

Readmissions

Georgia Tech students who find it necessary to discontinue enrollment for one or more quarters, with the exception of summer quarter, must apply for readmission when planning to return to the Institute. The student may obtain an application for readmission from the registrar and should return the completed form no later than the date indicated on the following schedule:

Quarter	Date
Fall	August 1
Winter	December 1
Spring	March 1
Summer	June 1

Former students on *drop* or *review* status should apply at least two months prior to these deadlines in order to ensure sufficient time for the review process. The section "Rules and Regulations" in this catalog contains additional information on readmissions.

Academic Advising

The faculty of each school must provide each student enrolled in that school the opportunity to consult with an informed adviser on the academic program and the selection of courses. Students should regularly seek assistance from their designated faculty advisers during their program of study, particularly when problems occur. Students who do not know the identity of their adviser should consult with the school director. Students undecided about their majors should seek advice from staff members in the office of the appropriate college dean.

Academic Regulations

The "Rules and Regulations" section of this catalog contains detailed information regarding the academic regulations of the Institute. Students who have questions concerning these regulations should consult either the general office of their major school or the Office of the Registrar, Room 104, Administration Building.

Grading System

For detailed information about the Georgia Tech grading system, see "Rules and Regulations," Section IV, in this catalog.

Graduate Course Option

Students who complete both the bachelor's and master's degrees in the same discipline at Georgia Tech may, with the approval of their major school, use up to nine credit hours of graduate-level course work (as approved by the major school) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within a two-year period from the award date of the bachelor's degree. Aerospace Engineering, Civil Engineering, Electrical Engineering, Engineering Science and Mechanics, Industrial and Systems Engineering, Mathematics, and Mechanical Engineering are the only Schools currently participating in this program.

Institute Rules for the Pass/Fail System

At the option of the major school, a student may receive up to a maximum of twelve hours credit toward a bachelor's degree or six hours credit toward a graduate degree for courses taken under the pass/fail system with a grade of *pass*. Such courses apply toward the degree requirements only if the major school has approved the course, either for all majors or for the individual student. The department or school offering a course determines the criteria for a passing grade and may restrict the pass/fail enrollment in any course it offers. The rules for withdrawal from graded courses apply to pass/fail courses as well.

Professors will record only a grade of *pass* or *fail* for any student so designated on the official class roll; students may not change their designation from credit to pass/fail or from pass/fail to credit after the last day to make schedule changes. Neither the professor nor the registrar may change a pass/fail grade to a letter grade, nor may the registrar include courses taken pass/fail in the calculation of grade point averages.

Under certain circumstances, a change in degree requirements may affect a department's position on a course previously approved for degree credit under the pass/fail system. In such cases, the student's major school will decide if a course completed with a grade of *pass* before the change will fulfill the amended requirements.

Only students who complete 180 or more hours toward a degree at Georgia Tech may use the entire maximum of twelve hours credit taken on pass/fail toward a bachelor's degree. For transfer students, second undergraduate degree students, and dual degree students, the number of hours completed at Georgia Tech determines the maximum number of pass/fail hours allowed, according to the following schedule:

Hours included in program of study	Hours allowed on pass/fail basis
50 to 89 credit hours	3 credit hours
90 to 134 credit hours	6 credit hours
135 to 179 credit hours	9 credit hours
180 or more credit hours	12 credit hours

Examination and Grade Reports

The Institute schedules final examinations during the last week of each quarter and issues grade reports of the student's academic progress after the quarter's close.

Scholastic Average

A student who passes a course receives both the designated number of credit hours and a number of quality points, calculated by multiplying the course credit hours and the numerical equivalent of the letter grade received (A = four, B = three, C = two, D = one). Thus, a student taking a three-hour credit course and earning a grade of C receives six quality points. To determine the undergraduate scholastic average, the total number of quality points earned by the student for all courses scheduled as an undergraduate is divided by the total number of credit hours scheduled; for the graduate scholastic average, only those courses scheduled by the student while enrolled in the

graduate division are considered. If a student takes the same course more than once, the later grade does not replace the earlier one; rather, the scholastic average includes both grades. Courses taken pass/fail are not included in the calculation of grade point averages.

Second Undergraduate Degrees

To be a candidate for a second undergraduate degree, a student must obtain the recommendation of the faculty through the director of the school concerned and the approval of the Undergraduate Curriculum Committee. This is accomplished by submitting the proposed program of study prior to beginning course work. Should course work be taken prior to receiving the school recommendation and committee approval, the course work completed may have to be used, as applicable, toward the first degree only. See Student Rules and Regulations, Section XIII D for additional information.

Transfer Credit

The basic policy regarding the acceptance of courses by transfer is to allow credit for courses completed with satisfactory grades (C or better) in other accredited colleges, provided the courses correspond in time and content to courses offered at the Georgia Institute of Technology. Georgia Tech will not accept credit (except by examination) for courses successfully completed at another institution but previously failed at Tech. The student must request and file an official transcript of transfer courses before the Institute can award credit.

Enrolled students at Georgia Tech must receive prior approval from the student's major school and the registrar before scheduling courses at other institutions. Students are not to be enrolled at Georgia Tech and another college without specific approval of the registrar and the appropriate faculty committee.

Auditors

Officially enrolled students who have obtained approval of their advisers and the department of instruction concerned may audit courses at Tech; however, the student will not receive credit for courses scheduled on an auditing basis. If the student wishes to change to or from auditing status, he or she must follow the procedure for schedule changes during the time allotted for schedule modification in the official calendar. All students registered as auditors must pay tuition at the regular rate. Members of the faculty or staff of the Georgia Institute of Technology may sit in on a course with the permission of the department concerned and the registrar.

Constitution and History Examinations

The Georgia law as amended March 4, 195? requires that before receiving an undergraduate degree all students pass examinations or comparable courses in United States and Georgia history as well as United States and Georgia Constitution. Courses that fulfill the United States and Georgia Constitution requirements are POL 1251 or POL 3200. Courses that fulfill the United States and Georgia history examination requirement are HIST 1001 or HIST 1002.

Regents' Testing Program

To establish eligibility for an undergraduate degree, every student in the University System of Georgia must pass the Regents' Test, an examination designed to measure proficiency in reading and English composition. Students are invited to take this examination when they have earned ten hours of course credit. Any student accumulating fifty hours of course credit toward a degree without passing the Regents' Test must schedule remedial English along with other credit course work. If a student fails in the first attempt, he or she must repeat the test. Alternative tests of competence are offered to nonnative speakers of English through the Department of Modern Languages.

ROTC Credit

Students may apply a maximum of six quarter hours in basic ROTC courses and nine quarter hours in advanced ROTC courses toward meeting the requirements for any degree. Students should begin taking basic ROTC courses during the first quarter they are enrolled. For further information, see individual curricula for the schools.

Physical Education

All students attending Georgia Tech must satisfactorily complete physical education requirements, PE 1040 or 1061, during their freshman year. Individual schools must allow a minimum of three hours of physical education credits and may allow as many as six hours of 1000- and 2000-level courses to be counted toward degree requirements. Students should check the curricula of their individual schools in order to determine the number of hours they may apply toward the degree. PE 3100 may be used to satisfy four hours of free electives or technical electives if approved by the major school.

The Health Information Record will determine any medical exemptions from physical education courses. The Department of Physical Education and Recreation will accept certificates of disability from personal physicians only after the Student Health Service has endorsed the documents.

For a complete description of the physical education requirements at Georgia Tech, refer to the Department of Physical Education and Recreation listed under the College of Sciences and Liberal Studies in the "Curricula and Courses of Instruction" section of this catalog.

Humanities and Social Sciences Requirements

This catalog lists in the section "Curricula and Courses of Instruction" a tabulation of the courses required for degrees in the curricula offered by Georgia Tech.

All curricula leading to an undergraduate degree must include at least thirty-six hours of humanities and social sciences according to the following distribution:

At least eighteen hours of humanities (including at least three hours of literature) selected from the following subjects:

English: 1001, 1002, 2004, 2031, 2032, 2033, 2037, 2038, 2039, 2101, 2201, 2301, 2401, 3006, 3037, 3038, 3039, 3041, 3042, 3043, 3044, 3051, 3056, 3058, 3059, 3072, 3076, 3081, 3082, 3083, 3084, 3085, 3086, 3101, 3131, 3151, 3152, 3161, 3181, 3201, 3203, 3205, 3221, 3225, 3227, 3251, 3401, 3402, 3411, 3412, 3461, 3462, 3483, 3501, 3502, 3786, 3881, 3882, 3883, 4042, 4081, 4082, 4083, 4132, 4755, 4801, 4803, 4811, 4813, 4821, 4823, 4833, 4843.

Modern Languages:
French, Spanish, Russian, German 1001, 1002, 1003.
Foreign Languages: 1001, 1002, 1003, 1011, 1012, 1013, 1021, 1022, 1023, 1032, 1033.

Students in the College of Engineering may include up to nine hours of 1000-level foreign language courses (twelve hours in Russian) for humanities credit provided they complete nine additional hours in the same language on the 2000 or higher level; otherwise, the 1000-level courses will count as free electives. This regulation does not apply to linguistics courses.
German: 3001, 3002, 3003, 3004, 3031, 3032, 3033, 3041, 3042, 3043, 3051, 3760, 4001, 4002, 4003, 4021, 4022, 4023, 4051, 4052, 4053.
Russian: 3761, 4901.
Spanish: 3001, 3002, 3003, 3006, 3011, 4021, 4022, 4023, 4024, 4025, 4026, 4031, 4032.
French: 2021, 2022, 2023, 3001, 3002, 3003, 3004-5-6, 3007-8-9, 4001, 4002, 4003.
Linguistics: 1001, 1002, 1003, 2001, 2002, 2003, 3001, 3002, 3003, 3004, 3005, 4002, 4003, 4901. (Students in the College of Engineering may not use Linguistics 3001, 3002, 3003 as humanities credits.

Music: 2201, 2202, 2203, 3201, 3202, 3203, 3400.

Architecture: 1201, 1202, 1203, 3201, 3202, 3203, 3204, 3205, 4204, 4205, 4206, 4207, 4208, 4209, 4247, 4248, 4249.

Industrial Design: 1263.

At least eighteen hours of social sciences (including at least three hours of American history—HIST 1001 or HIST 1002—and three hours of American government—POL 1251 or POL 3200) selected from the following subjects:

History: 1001, 1002, 1028, 3001, 3003, 3004, 3005, 3006, 3007, 3008, 3012, 3013, 3015, 3016, 3017, 3018, 3020, 3022, 3024, 3025, 3026, 3027, 3028, 3030, 3040, 3047, 3048, 3049, 3786, 4008, 4016, 4025, 4050, 4075, 4875, 4876, 4877, 4925, 4926, 4927, 4928, 4929.

Philosophy of Science and Technology: 1126, 1127, 3100, 3102, 3103, 3104, 3105, 3107, 3113, 3120, 3121, 3122, 4110, 4115, 4757, 4875, 4876, 4877, 4944, 4945, 4946, 4947, 4948, 4949.

Political Science: 1251, 3200, 3203, 3204, 3205, 3210, 3211, 3215, 3216, 3217, 3220, 3221, 3250, 3265, 3266, 3270, 3275, 3276, 3280, 3281, 4205, 4210, 4211, 4212, 4250, 4755, 4875, 4876, 4877, 4950, 4952, 4953, 4954, 4955, 4956.

Sociology: 1376, 1377, 1378, 1379, 3306, 3335, 3338, 3339, 3340, 3501, 3875, 3876, 3877, 4306, 4311, 4756, 4875, 4876, 4877, 4999.

Modern Languages:
Foreign Languages: 2011, 2012, 2013, 2021, 2022, 2023.
German: 2001, 2002, 2003, 2051, 2052, 2053, 3011, 3012, 3013.
French: 2001, 2002, 2003, 3011, 3012, 3013, 3021, 3022, 3023.
Russian: 2001, 2002, 2003, 4902.
Spanish: 2011, 2012, 2013, 3004, 3005, 3007, 3008, 3009, 3012, 4007, 4008, 4009, 4010.
Linguistics: 4001, 4902.

Psychology: 3300, 3303, 3304, 4400, 4402, 4410, 4423, 4424, 4750, 4755.

Economics: 2000, 2001, 3000, 3001, 3002, 3400, 3500, 3501, 3502, 4300, 4332, 4340, 4341, 4400, 4420, 4500.

Sociotechnology (to be used by students in the College of Engineering only):
Civil Engineering: 4143.
Nuclear Engineering: 4720.
Industrial and Systems Engineering: 4756, 4757.

Architecture: 4210, 4221.

General Information

The faculty of the Georgia Institute of Technology grants advanced degrees in engineering, science, management, architecture, and city planning. The goals for graduate studies and research are to establish an educational environment that will encourage and assist students to develop their capabilities both as professionals and as human beings, to encourage students and faculty to press research vigorously for the discovery and generation of new knowledge, to investigate ways of applying such knowledge innovatively for the benefit of society and humanity, and to foster the development of new tools, objects, and ideas.

Students whose interests and aptitudes lead them beyond the limits of the traditional undergraduate curriculum may broaden their knowledge of a given field and pursue independent inquiry through graduate study. A graduate education is of particular benefit to students interested in careers in research, management development, design, or consulting; to those who aspire to formulate and administer policy; and to those who desire to enter the profession of education in the fields of architecture, engineering, management, or science.

Degrees and Programs of Study

Master's Programs

Programs of study and research leading to the Master of Science are offered in the following disciplines:
Aerospace Engineering
Applied Biology
Applied Mathematics
Applied Physics
Architecture
Atmospheric Sciences
Ceramic Engineering
Chemical Engineering
Chemistry
City Planning
Civil Engineering
Electrical Engineering
Engineering Science and Mechanics
Environmental Engineering
Geophysical Sciences
Health Physics
Health Systems
Industrial and Systems Engineering
Information and Computer Science
Management
Mechanical Engineering
Metallurgy
Nuclear Engineering
Operations Research
Physics
Polymers
Psychology
Statistics
Technology and Science Policy
Textile Chemistry
Textile Engineering
Textiles

Doctoral Programs

Programs of study and research leading to the Doctor of Philosophy are offered in the following disciplines and areas:

Aerospace Engineering
Applied Biology
Architecture
Atmospheric Sciences
Ceramic Engineering
Chemical Engineering
Chemistry
Civil Engineering
Economics
Electrical Engineering
Engineering Science and Mechanics
Environmental Engineering
Geophysical Sciences
Health Physics
Industrial and Systems Engineering
Information and Computer Science
Management
Mathematics
Mechanical Engineering
Metallurgy
Nuclear Engineering
Operations Research
Physics
Psychology
Textile Engineering and Science

To locate detailed descriptions of these programs and related courses, please refer to the index on pages 319-320 of this catalog.

The Institute may award degrees with or without designation of the field, based upon the recommendation of the school concerned.

Special Programs

Interdisciplinary Programs

The schools of the Institute authorized to offer graduate degrees develop and administer their own individual programs and work closely with one another to provide special study and research opportunities for students who wish to pursue a degree with a wider perspective than that presented by a single discipline.

Cooperation between academic units and various research centers and the development of informal programs based on areas of faculty interest, has resulted in the establish ment of interdisciplinary programs in a number of areas: computer integrated manufacturing systems, atomic collisions, complex systems design, radiological health, solid waste technology, transportation, and surface science technology. The College of Engineering lists a large number of multidisciplinary programs on page 83 of this catalog.

Graduate Cooperative Program

Selected students planning to enroll for graduate study at Georgia Tech have the opportunity to participate in a unique cooperative program leading to advanced degrees in participating schools. Two plans are available. One is designed for Georgia Tech undergraduates who plan to continue as graduate students at Tech and includes study work periods that span both undergraduate and graduate levels. Eligibility is based on academic achievement at Georgia Tech. The second plan is for graduate students whose undergraduate degrees may be from Tech or other institutions. Most participating companies require United States citizenship or permanent residency.

Degree requirements under this plan are identical to those for all students enrolled at Georgia Tech. The Graduate Cooperative Plan is designed as an enhancement to the educational programs of students working for advanced degrees and offers the benefits of added facilities and opportunities for external stimulation. In addition, students receive compensation for their services from companies that employ them.

Preliminary screening of students occurs at the School or College level. The participating companies select students on the basis of academic credentials and interest areas correlated to company activities. The program requires at least two work quarters at the undergraduate level and a least two work quarters at the graduate level for students planning to participate both at the undergraduate and graduate levels. Students planning to participate only at the graduate level are required to work at least two quarters.

Students interested in applying for admission to the Graduate Cooperative Plan should write to the Director, Graduate Cooperative Program, Office of Graduate Studies and Research, Georgia Institute of Technology, Atlanta, Georgia 30332-0265.

The Academic Common Market

The Institute participates in the Academic Common Market Program managed by the Southern Regional Education Board. By interstate agreement, the market enables southern states to share academic programs. Residents of the participating states who qualify for admission and gain the approval of their state coordinators may enroll on an in-state tuition basis. Georgia Tech programs include architecture (MS), atmospheric sciences (MS), ceramic engineering (MS, Ph.D.), city planning (MS), geophysical sciences (Ph.D.), health physics (MS), health systems (MS), nuclear engineerng (MS, Ph.D.), and textile engineering (Ph.D.).

Policies and Regulations

Though final authority rests with the Academic Senate, the Graduate Committee, with the approval of the Senate, is responsible for establishing academic policy for the graduate program. This committee reserves the right to change requirements for degrees as may be appropriate. Students enrolled at the time such changes appear in the catalog have the privilege of following either the regulations stated in the catalog effective the quarter in which they enrolled or the regulations in the catalog that records the change.

This catalog records the Institute-wide policies and regulations that govern the graduate program. Schools may make additional rules concerning programs and the pursuit of their degrees, but these rules may not contradict Institute policies and regulations.

Graduate Student Work Loads

Full-time students must enroll for at least twelve hours. The maximum load for full-time students is twenty-one hours, and the minimum load for part-time students is three hours.

Students supported by assistantships must enroll for twenty-one hours, at least twelve of which must be on a letter grade or pass/fail basis. Teaching assistants and nonthesis research assistants must include audit hours in recognition of teaching (8997) and research (8998) activities, as appropriate. Thesis research assistants may include activity audit hours in addition to thesis research hours (7000 or 9000).

Students with fellowships, traineeships, tuition waivers, or student visas and those assigned to the Institute by the Armed Forces for the purpose of pursuing a degree are required to be enrolled for at least twelve credit hours, excluding audit.

Further information on student loads is available from the Office of Graduate Studies and Research.

Staff Members

No staff member beyond the rank of instructor in a school may work for a master's degree in that school.

No new staff member with the rank of assistant professor in a school may work for a doctoral degree in that school.

Admissions Information

Prospective students may obtain information and the necessary forms for admission from either the appropriate school or the Office of Graduate Studies and Research. The student must submit the application, letters of recommendation, and official transcripts of previous academic work to the offices specified on the form by August 1, December 1, March 1, and June 1 for fall, winter, spring, and summer quarters, respectively. Deadlines for international students are one month earlier; however, it is strongly recommended that international students submit their materials at least six months before the proposed registration date. A $15 application fee is required. To receive a graduate studies brochure and financial aid booklet, write to the Office of Graduate Studies and Research, Georgia Institute of Technology, Atlanta, Georgia 30332-0265.

Graduate Record Examinations

Certain programs may require applicants to submit results of the General and Subject tests of the Graduate Record Examinations (GRE).

Students applying to the Schools of Applied Biology, Geophysical Sciences, Industrial and Systems Engineering, Information and Computer Science, Psychology, and Textile Engineering must file GRE General test scores. Applicants to the Schools of Chemistry, Information and Computer Science (Ph.D. applicants only), and Mathematics must file both General and Subject tests scores of the GRE. Students applying to the College of Management are required to supply General Management Aptitude Test scores (GRE General test scores preferred for Ph.D. applicants) and have them sent directly to the dean of the College of Management.

Information concerning times and locations for these tests can be obtained from Graduate Record Examinations, Educational Testing Service, Box 955, Princeton, NJ 08540. Students in western states should write to 1947 Center Street, Berkeley, CA 94704.

General information on the GMAT is available from Educational Testing Service, Box 966, Princeton, NJ 08540.

On-campus applicants may pick up GRE information from the Graduate Office and GMAT information from the College of Management.

Types of Standing

Applicants holding a bachelor's degree in an appropriate field from an approved institution will be accorded *full graduate standing* provided their previous work is of sufficient quality to indicate immediate success in advanced study.

If the work of an applicant holding an approved bachelor's degree is deficient in content or quality so that supplemental study or demonstrated ability is necessary, the applicant may be accorded *conditional graduate standing*.

Students who do not wish to qualify for an advanced degree at Tech, but demonstrate the potential benefits of their participation in advanced study, may gain admission as *special graduate students*. Students who are designated special standing for failure to submit official transcripts or for other administrative reasons may credit not more than twenty-four quarter hours taken on special standing toward a degree.

Graduate students in good standing at other universities may enroll at Tech as *transient graduate students* by filing an application for admission and verification of good standing status from their own graduate dean. However, work undertaken in this program will not apply toward a Georgia Tech degree.

The undergraduate school, not the graduate school, will register students working toward a second bachelor's degree.

In addition to full, conditional, and special graduate standing, graduate students will be classified by academic standing according to their grade point averages— good standing, warning, probation, or drop. For specific information, see "Rules and Regulations," pages 280-281.

Readmission

Students who interrupt the continuity of their graduate programs by not registering for one quarter (summer quarter excepted) must seek readmission by filing with the registrar a completed request for readmission form by August 1, December 1, March 1, or June 1 for fall, winter, spring, or summer quarters, respectively. Request forms are available from the registrar's office.

Reactivation of Application

Students admitted to the Tech graduate program who do not enter in the quarter for which they applied and subsequently wish to be considered for a later quarter must reactivate their application for the new quarter. Since the registrar's office keeps files on "never entered" students for one year only, these students will have to supply a new set of application materials if they delay more than one year in the reactivation request. To reactivate an application, the student must request reactivation in writing to the registrar by August 1, December 1, March 1, or June 1 for the fall, winter, spring, or summer quarters, respectively. The number of reactivations per applicant is limited.

Undergraduate Students

Seniors with a grade point average of at least 2.7 may schedule graduate courses. In order to do so, the student must obtain permission both from the student's adviser and from the director of the school offering the course.

Credit toward the master's degree for up to twelve hours of courses taken as an undergraduate may be received under the following conditions.

1. The student was in residence at the Georgia Institute of Technology for at least two quarters before registering for the course(s).

2. The student did not apply credit for the course toward the baccalaureate degree. (See page 39, "Graduate Course Option," for special exceptions in certain schools.)

Registration

During the week preceding first registration, each new student should consult with the director of the school of specialty to prepare a proposed program and to receive instructions regarding registration procedures.

Tech also conducts orientation for new graduate students in the fall quarter just before registration.

TOEFL for International Students

All international students from countries in which English is not the native language must take the Test of English as a Foreign Language (TOEFL). Since the results of this test constitute part of the material reviewed for admission to graduate study at Tech, students should arrange to have the Educational Testing Service send their scores to the registrar's office as early as possible. At present, the minimum score required for graduate admission is 550.

Students who wish to take the TOEFL should obtain the *TOEFL Bulletin of Information for Candidates, International Edition*. Applicants can acquire copies of the *Bulletin* and the registration form through the offices of the United States Information Service (USIS), American embassies and consulates, and United States educational commissions and foundations in a number of cities outside the United States. In addition, several private organizations distribute the *TOEFL Bulletin*. These groups include the Institute of International Education (IIE) in Nairobi, Kenya; Paris, France; and Lima, Peru; the African-American Institute (AAI) in Dar es Salaam, Tanzania and Lagos, Nigeria; the American Mideast Educational and Training Services (AMIDEAST) in Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt; and the American-Korean Foundation in Seoul, Korea.

Students who cannot obtain a *TOEFL Bulletin* and registration form locally should write well in advance of application to Test of English as a Foreign Language, Box 899, Princeton, NJ, U.S.A. 08540.

The Master's Degree

Prerequisites

Applicants for the master's program should have received a bachelor's degree from a recognized institution and graduated in the upper half of their class. Students must show evidence of preparation in their chosen field sufficient to ensure profitable graduate study.

Matriculation Requirements

While students may enroll in the master's degree program upon admission with either full or conditional standing, they must attain full graduate status to graduate with the M.S. degree.

Students enrolled for the master's degree must register for at least one quarter per year in order for the original requirements for their degree to remain unchanged. In other cases the school may re-evaluate the student's credentials and impose additional degree requirements.

Students who have completed all course work and are planning to submit a thesis in partial fulfillment of the requirements for a master's degree should register for research hours consistent with a realistic appraisal of the amount of remaining thesis work and required faculty involvement. Students will

not receive thesis guidance during any quarter for which they are not registered.

The Institute has no residency requirements for the master's degree.

Academic Requirements

The master's degree requires a minimum of forty-five approved credit hours distributed as follows:

With thesis:

Minimum course credit hours
in major field (a basic field
of knowledge, not a department
of specialization) 18
Minimum course credit hours
at 6000 to 9000 level 18
Total course credit hours
for degree 30
Thesis hours 15
Total credit hours 45

Without thesis (must have approval of school director):

Minimum course credit hours
in major field (a basic field
of knowledge, not a department
of specialization) 27
Minimum course credit hours
at 6000 to 9000 level 33
Total credit hours 45

Many schools require more than the minimum credit hours. Most M.S. programs in engineering require fifty credit hours.

The student must earn a graduate grade average of at least 2.7 and satisfy other requirements of the major school to be certified for a master's degree. To compute the grade point average, the registrar assigns grade points for all course work receiving grades, according to the following scale: $A =$ four, $B =$ three, $C =$ two, $D =$ one, $F =$ zero. The graduate average includes the grades on all courses scheduled by the student after admission to graduate study. Other than thesis hours, the student may use only six hours under the pass/fail designation in the approved program of study (see page 39).

Undergraduate courses required for graduation in the discipline (designated degree) or discipline-of-origin (undesignated degree) at Georgia Tech may not be applied toward a master's degree.

The student, in conference with the faculty adviser, should prepare a program of study for the master's degree as a guide for planning an academic schedule. In some cases, the student's school may require that the proposed program be submitted to the director of that school for approval.

Admission to Candidacy for the Master's Degree

Admission to graduate standing does not constitute acceptance as a candidate for an advanced degree. To obtain consideration for this privilege, the student must have shown evidence of ability to pursue a program of graduate study and research. A mere accumulation of credits is not sufficient. To apply for candidacy, the student must submit to the registrar, during the quarter preceding the anticipated final quarter of work, the petition for a degree with the approved program of study attached. To receive favorable action on this petition, the applicant must ordinarily have met the following requirements.

1. The student's approved program of study must show that course requirements for the master's degree will be satisfied during the final quarter (see Academic Requirements).

2. The student must have completed, or have scheduled to complete during the final quarter, any required work outlined at the time of matriculation.

3. The student must have an overall grade point average of at least 2.7 and satisfy all school academic requirements.

4. The student must have completed satisfactorily any language requirement imposed.

5. The student must have passed any qualifying or comprehensive examinations required by the student's school.

6. The student must have filed with the Office of Graduate Studies and Research an approved thesis topic and have made satisfactory progress on the thesis if it is a part of the approved program.

Requirements for Award of the Degree

Any candidate who meets the following requirements will normally be recommended to the Academic Senate to receive the master's degree:

1. has an overall grade point average of at least 2.7 and has satisfied all academic requirements of the major school;

2. receives final acceptance of the thesis from the graduate office and submits three unbound copies;

3. supplies the graduate office with a publishable thesis abstract of up to three hundred words, certified for accuracy by the thesis adviser;

4. satisfactorily completes the approved program of study (complete within a period of not more than six consecutive calendar years);

5. passes any general examinations, oral or written, required by the major school; and

6. is, at the time, a registered student. A **waiver of this requirement** may be obtained *only* if all requirements for graduation, including submission of the final approved thesis, have been met prior to the last day of registration *and* the student was registered for the preceding quarter.

Language Requirement

The student's school may require a reading knowledge of one appropriate language.

Transfer of Credit

The rules relative to and the process for obtaining transfer of credit for graduate-level courses are as follows.

1. A student may receive transfer credit (up to nine hours) for graduate-level courses taken elsewhere in the United States or Canada and not used for credit toward another degree. The student must supply a current transcript for this evaluation.

2. To obtain transfer of credit, the student must complete the following procedure: (a) The student will confer with the graduate adviser to ascertain whether the courses to be transferred are a logical part of the student's graduate program. The courses would typically be those appearing on the approved program of study form for the master's degree. A doctoral student normally does not request transfer credit. (b) If the courses are appropriate, the student will deliver to the school that teaches such courses a copy of the current transcript, necessary descriptive materials, including catalog descriptions, and textbooks used for evaluation. The faculty of the appropriate school will determine the equivalent Georgia Tech course and the number of credit hours accepted. The faculty member who prepares the transfer credit form should have the school director cosign it. The school should then send the form directly to the registrar with a copy of the student's Approved Program of Study attached. (c) If the student wishes to transfer more than nine hours, a petition must be submitted to the graduate committee including statements of possible justification for the granting of such a petition, transfer credit forms, and the recommendation of the student's school director.

3. A joint enrollment student may receive graduate credit for up to one-third of the hours required for the degree for graduate courses taken at Emory University or Georgia State University provided that (a) Tech does not offer such courses, (b) the student's adviser and school director approve the courses in writing in advance, and (c) the student passes the courses with a grade of C or better. "Advance approval" is satisfied when the courses appear on the student's proposed program of study.

4. A student may not receive transfer credit from universities outside the United States and Canada; however, an international student can obtain credit for courses previously taken but not applied toward another degree by filling out an "Examination for Advanced Standing Authorization Request Form," paying the appropriate fee at the Cashier's Office, and passing the examination for advanced standing. The school or department that normally teaches the equivalent course will administer any necessary examinations.

The Master's Thesis

To complete the requirements for the master's degree, the student must submit a master's thesis unless the school director

determines that additional course work is of more importance in meeting approved objectives.

Students who meet the requirements for the master's degree by completing a combination of course work and thesis must register for a minimum of fifteen hours of thesis credit. (See section on academic requirements.)

A candidate whose program includes a thesis must present a treatise in which the results of an investigation directed by a member of the faculty of the Institute are set forth in clear, articulate form. The purpose of the thesis is to further the educational development by requiring the student to plan, conduct, and report an organized and systematic study of importance.

The Manual for Graduate Theses, available from the graduate office, specifies the requirements for the thesis.

The Doctoral Degree

The degree of Doctor of Philosophy recognizes demonstrated proficiency and high achievement in research. After adequate preparation, the candidate must complete a searching and authoritative investigation of a special area in the chosen field, culminating in a written dissertation covering that investigation. The dissertation must be either an addition to the fundamental knowledge of the field or a new and better interpretation of facts already known. It must demonstrate that the candidate possesses powers of original thought, talent for research, and ability to organize and present findings.

Matriculation Requirements

Ordinarily, the graduate school admits to the doctoral program only those students who have graduated in the upper quarter of their class.

The matriculation requirements are identical to those outlined for the master's degree except for the residency requirement. Doctoral students must spend at least three full-time quarters in residence at the Georgia Institute of Technology and ordinarily must complete research for the dissertation while in residence. Under special circumstances, however, candidates who have met the resi-

dence requirement may receive permission pursue their research in absentia, provided the director of the appropriate school approves and a faculty member directs the project.

Admission to Candidacy

Doctoral students customarily apply for degree candidacy after completing at least five quarters of course work beyond the B. degree.

To qualify for candidacy, students must complete all course requirements (except the minor), achieve a satisfactory scholastic record, and pass the comprehensive examination. In addition, the student must file with the school director, and the Office of Graduate Studies and Research a formal statement naming the dissertation adviser and delineating the research topic, the purpose of the investigation, and a proposed methodology for its completion.

Upon satisfactory completion of these requirements, with approval of the dissertation topic, the graduate school formally admits the applicant to candidacy for the degree.

The comprehensive examination assesses both general knowledge of the degree area and specialized knowledge of the student's chosen research field. Each school is responsible for scheduling comprehensive examinations at least once a year, in the fall or spring, and for informing students of their scope. A guidance committee appointed by the director of the school will advise each student in planning a program of study and preparing for the examination, partly through an initial evaluation of the student's background and interests, partly through periodic consultation to evaluate and aid the student's progress.

Students must complete all degree requirements within five years from the end of the quarter in which they pass the comprehensive examination and must have an overall grade point average of 2.7 in order to graduate. During the quarter preceding the anticipated final quarter of work, the candidate must submit a petition for the degree to the registrar. Petition forms are available in the registrar's office.

Major and Minor Fields of Study

While no fixed course requirements apply for the doctoral degree, the student must include in two or more years of graduate course work both a major and a minor field of study.

In addition to an adequate knowledge of the major field of intended research, the student must demonstrate mastery of some other, smaller body of knowledge—the minor field—preferably outside the student's particular school. The purpose of the minor is to encourage a wider interest on the part of the student and to provide a broader basis for the evaluation of the student's capabilities.

The minor will normally consist of at least fifteen quarter hours of work in related courses, chosen by the student in consultation with a guidance committee and approved by the Office of Graduate Studies and Research. These courses should be at the 6000 level or above, but certain 4000-level courses may also be used with proper approval. Courses taken at other institutions may be included in the minor. However, a minimum of fifteen hours of course credit, approved by the student's thesis advisory committee, must be completed on a letter grade basis while enrolled at Georgia Tech. Once the student has satisfactorily completed the minor, the school director sends a confirmation, accompanied by course grades, to the graduate office for final approval and recording.

Although the student need not complete the minor as a prerequisite for admission to candidacy, the chosen field must be submitted for approval and the program of study must be completed before clearance for the degree.

Language Requirements

The student's school may require a reading knowledge of one or more foreign languages.

The Dissertation

Prior to the student's admission to candidacy, the candidate will present for the approval of the school director, college dean, and the Office of Graduate Studies and Research a

formal statement naming the student's dissertation adviser and setting forth the topic selected for investigation, the objectives the student hopes to gain, and the steps by which the student proposes to gain them. The dissertation topic must give promise of being either a genuine addition to the fundamental knowledge of the field or a new and better interpretation of facts already known.

The dissertation must meet the criteria published in the *Manual for Graduate Theses*, which is available in the Office of Graduate Studies and Research.

Prior to the final submission of the completed dissertation to the graduate office, the student must pay the Institute a fee of $40 for microfilming the dissertation through University Microfilms, Inc.

The Doctoral Examination

If the dissertation advisory committee finds the dissertation satisfactory, it schedules the candidate for an oral examination on the subject matter for the dissertation and the field in which it lies. An examining committee approved by the Office of Graduate Studies and Research will conduct the examination. The student must register for the quarter in which the final examination occurs and for the quarter of graduation. A waiver of this requirement may be obtained *only* if all requirements for graduation, including submission of the final approved dissertation, have been completed prior to the last day of registration, and the student was registered for the preceding quarter.

If both the dissertation and the examination are satisfactory and the candidate has completed the requirements of residence, minor field, and any additional school requirements, the Office of Graduate Studies and Research will certify the candidate as qualified to receive the degree of Doctor of Philosophy.

If a candidate should fail to pass the final oral examination, the examining committee may recommend permission for one additional examination. In the case of failure, the registrar does not receive a report of the examination results, but the Office of Graduate Studies and Research keeps a record on file.

Financial Information

Classification of Students for Tuition Purposes

Under the Constitution and laws of Georgia, the Board of Regents of the University System of Georgia was created to govern, control, and manage a system of public institutions providing quality higher education for the benefit of Georgia citizens. The State, in turn, receives substantial benefit from individuals who are attending or who have attended these institutions through their significant contributions to the civic, political, economic, and social advancement of the citizens of the state of Georgia.

Because the overwhelming proportion of financial support for the operation of the public institutions of higher education in Georgia comes from the citizens through the payment of taxes, the determination of whether a student is classified as a resident or a nonresident of the state for tuition purposes becomes a significant matter. The tuition paid by in-state students covers only about one-fourth of the total cost of their education in the University System. Therefore, Georgia taxpayers are contributing three-fourths of the necessary funds to provide quality education for the citizens of the state.

The practice followed by state colleges and universities of assessing out-of-state students a higher tuition rate is a rational attempt by states to achieve a partial cost equalization between those who have and those who have not recently contributed to the state's economy, even though no precise way exists to determine the degree to which higher tuition charges equalize the cost of educating in-state and out-of-state students.

Courts that have been faced with challenges to residency classification procedures have consistently recognized the right of public institutions of higher education to charge higher rates to out-of-state students and to adopt reasonable criteria for determining the establishment of in-state status.

For the purpose of these regulations, the question to be answered is not primarily whether a student is a resident or nonresident of Georgia, but rather whether the student meets the criteria to pay University System fees on an in-state basis. The term "resident" is confusing because it may have several definitions as it relates to voter registration, driver's licenses, automobile registration, deeds, contracts, wills, income taxes, and other matters. A student may be a resident of Georgia for some purposes, but not entitled to in-state status for tuition purposes.

The Board of Regents has adopted certain policies governing the classification of students as residents and nonresidents for tuition purposes in keeping with its responsibilities to the citizens of Georgia for an appropriate assessment of fees and to ensure that out-of-state students pay a fair and reasonable share of the cost of their education. The taxpayers of Georgia are thereby assured that they are not assuming the financial burden of educating persons whose presence in the state is not intended to be permanent.

With these considerations in mind, the Board of Regents has adopted the below-listed policies governing the classification of students for fee payment purposes.

1. (a) If a person is eighteen years of age or older, he or she may register as an in-state student only upon showing that he or she has been domiciled in Georgia for a period of at least twelve months immediately preceding the date of registration.

(b) No emancipated minor or other person eighteen years of age or older shall be deemed to have gained or acquired in-state status for tuition purposes while attending any educational institution in this state, in the absence of a clear demonstration that he or she has in fact established legal residence in this state.

2. If a person is under eighteen years of age, he or she may register as an in-state student only upon showing that his or her supporting parent or guardian has been a legal resident of Georgia for a period of at least twelve months immediately preceding that date of registration.

3. If a parent or legal guardian of a minor changes his or her legal residence to another state following his or her legal residence in Georgia, the minor may continue to take courses for a period of twelve consecutive months on the payment of in-state tuition. After the expiration of the twelve-month period, the student may continue his or her registration only upon the payment of fees at the out-of-state rate.

4. In the event that a legal resident of Georgia is appointed as guardian of a nonresident minor, such minor will not be permitted to register as an in-state student until the expiration of one year from the date of court appointment, but only upon a proper showing that such appointment was not made to avoid payment of the out-of-state fees.

5. Aliens shall be classified as nonresident students provided, however, that an alien who is living in this country under an immigration document permitting indefinite or permanent residence shall have the same privilege of qualifying for in-state tuition as a citizen of the United States.

6. Waivers: An institution may waive out-of-state tuition for:

(a) nonresident students who are financially dependent upon a parent, parents, or spouse who has been a legal resident of Georgia for at least twelve consecutive months immediately preceding the date of registration provided, however, that such financial dependence shall have existed for at least twelve consecutive months immediately preceding the date of registration;

(b) international students selected by the institutional president or his authorized representative, may be enrolled upon the payment of in-state tuition provided that the number of such waivers in effect does not exceed one percent of the equivalent full-time students enrolled at the institution in the fall quarter immediately preceding the quarter for which the out-of-state tuition is to be waived;

(c) full-time employees of the University System, their spouses, and their dependent children;

(d) nonresident graduate students who hold teaching or research assistantships requiring at least one-third time service at such institution;

(e) full-time teachers in the public schools of Georgia and their dependent children. Teachers employed full time on military bases in Georgia shall also qualify for this waiver;

(f) career consular officers and their dependents who are citizens of the foreign nation that their consular office represents and who are stationed and living in Georgia under orders of their respective governments. This waiver shall apply only to those consular officers whose nations operate on the principle of educational reciprocity with the United States;

(g) military personnel and their dependents stationed in Georgia and on active duty unless such military personnel are assigned as students to System institutions for educational purposes.

For further information concerning residency, students should contact the Residency Office, Room 104, Administration Building in writing or by telephone (404/894-4158). The Residency Office must receive an application for classification as a legal resident for fee payment purposes no later than one month prior to the academic registration date for the quarter in which the student seeks to pay fees as a resident of Georgia.

Undergraduate Information

Costs (1987-88 Academic Year)	Resident of Georgia	Nonresident of Georgia
Quarterly Fees		
Matriculation	$506	$506
Nonresidence	$ 0	$1,235
Transportation	$ 9	$ 9
Student Activity	$ 30	$ 30
Health Service	$ 46	$ 46
Athletic	$ 30	$ 30
Subtotal	$621	$1,856
Books and Supplies	$145	$145
Room and Board	$1,130	$1,130
Personal Expenses		
(clothing, laundry, recreation, etc.)	$240	$240
Total Per Quarter	$2,136	$3,371
Total Per Year (3 quarters)	$6,408	$10,113
Total Per Year (2 quarters) for co-op students in school 2 quarters instead of 3	$4,272	$6,742
Additional Freshman Expenses (pocket calculator, drawing supplies—in addition to quarterly costs)	$155	$155
Total Per Year (freshmen only)	$6,563	$10,268

A nonrefundable fee of $15 must accompany all applications for admission to the Georgia Institute of Technology. Upon registration, part-time students (those carrying less than twelve credit hours per quarter) who are legal residents of Georgia pay $39 per credit hour and a transportation fee of $9. Non-resident part-time students pay $134 per credit hour ($39 matriculation and $95 tuition) and a transportation fee of $9.

All students scheduling six hours or more must pay the student activity fee of $30, the athletic fee of $25, and the health service fee of $44.

Since changes in fees may occur without notice, the student must refer to information provided on registration day by the Office of the Vice-president for Business and Finance for official amounts on fees and other institutional charges for each individual quarter.

Obligations of Students

An individual is officially enrolled at Georgia Tech upon payment of all applicable matriculation, tuition, transportation, student activity, athletic, and student health fees for the current quarter. Upon enrolling, every student is obligated to remit, return, or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures that may be taken pursuant to the Student Conduct Code, "Rules and Regulations."

It is the responsibility of the student to be informed of and to observe all regulations and procedures regarding the payment of fees and the entitlement to refunds. In no case will a regulation be waived or an exception be granted because a student pleads ignorance of the regulation or asserts that he or she was not informed of it by an adviser or other authority. All questions concerning fees and refunds should be directed to the Collections Department only. Verbal misinformation is not grounds for a waiver of a regulation.

All fees are payable by the deadline published in the Schedule of Classes for each academic quarter. Registration is not complete until all fees have been paid. Payment may be made either in cash (at a Teller Window in the Cashier's Office) or by check payable in United States currency and drawn on a financial institution in the United States of America. The Institute reserves the right to determine the acceptability of all checks. All checks not drawn in this manner will be returned to the remitter of the check. Counter checks are not acceptable. If a check given in payment of a student's fees, books, supplies, or residence hall rent is not paid upon presentation to the bank on which it is drawn, an academic hold will be placed on the student's records. A student with an academic hold on his or her record will not be permitted to register for further course work or receive, or have forwarded to external third parties, transcripts of grades until the financial obligation represented by the returned check plus a returned check fee of $15 or 5 percent of the face amount of the check, whichever is greater, has been paid. Any person who issues an "insufficient funds" or "no account" check may have violated the statutes of the state of Georgia. This person may not only be permanently withdrawn from the Institute, but may also face legal prosecution. Any person who has a check returned by the bank for any reason should settle that obligation promptly. Failure to do so may result in the placing of the account for collection by a professional collection agency, with the student incurring the full cost of collection.

All matriculation and other charges are subject to change without notice.

Late Registration Fee

Late registration will incur a penalty fee of not more than $100, at the rate of $50 for the first day after regular registration and an additional $25 for each of the next two days. If a student does not pay all required fees by the end of the first week of the quarter, his or her registration will be canceled.

Laboratory and Breakage Fees

Chemistry Breakage Cards may be purchased at the Cashier's Office. Each card costs $10, and refunds are made for the unused portion during the last two weeks of each quarter.

Duplicate Fee Receipts

A student who has lost his or her fees-paid receipt is entitled to receive a duplicate upon written request to the Cashier's Office. A charge of $1 will be made for each duplicate receipt. There is a forty-eight hour processing period for duplicate receipts.

Other Fees

The fees listed here do not include fraternity, club membership, or personal transportation expenses.

Each student petitioning for graduation must pay a graduation fee upon submitting the petition. The charge is currently $25. Students must pay this fee each time they submit a petition for graduation.

Each accepted applicant for admission to the fall quarter must submit a deposit (in addition to the residence hall room deposit) as stated in the letter of admission. Approximately two weeks following the first day of classes, the student will receive a refund of this deposit by check. The student will be notified in his or her post office box when the check is ready in the Cashier's Office.

Georgia Tech reserves the right to charge a fee for the use of Institute property and to levy fines for the improper use of Institute property.

Refund of Fees

If a student must withdraw from the Institute, the administration will consider requests for fee refunds only through written application.

The student should obtain a refund request from the registrar or the Cashier's Office and submit the form, dated and signed, with a copy of the withdrawal application to the Collections Department, located in the Knowles Building, within one month of the registration date.

Students withdrawing on or before the last day to register without penalty are entitled to a 100 percent refund. Students withdrawing during the four-week period beginning with the first day on which the late fee applies are entitled to a refund of a certain percentage of matriculation and tuition fees paid for that quarter as follows.

Withdrawal Effected	Percent Refunded
One week following registration	80%
Two weeks following registration	60%
Three weeks following registration	40%
Four weeks following registration	20%

Students should refer to the Schedule of Classes for specific dates and times of each refund period. The date to be used in determining eligibility for a refund will be the date the withdrawal is executed in the Office of the Registrar.

After the last day to register without penalty, the following students are not entitled to any refund of fees paid:

Students who withdraw after a period of four weeks has elapsed from the last day to register without penalty.
Students who have been suspended for disciplinary reasons.
Students who leave the Institute when disciplinary action is pending.
Students who do not withdraw formally.

A stop payment of a check does not constitute a formal withdrawal. There will be a returned check fee of $15 or 5 percent of the face amount of the check, whichever is greater, as previously stated; the student will be held liable for tuition and fees until the date of official withdrawal.

Requests for refunds must be made in writing to the Collections Department, in Knowles Building, at the time of withdrawal.

Undergraduate Financial Assistance

The primary purpose of financial aid at Georgia Tech is to provide assistance to students who, without such aid, would be unable to attend college. The financial aid office receives and administers all funds provided to Tech for undergraduate student assistance, including awards forwarded to the Institute from outside agencies for the use of designated students. Because Georgia Tech will assist students either by awarding funds or by directing the student to other sources of aid, no student should fail to consider attending Tech because of financial problems. However, the financial aid applicant should realize that the amount of aid granted seldom meets all educational expenses, and financial assistance from the Institute will require supplements from the student, family members, and outside sources.

The primary responsibility for financing an education rests with the student and his or her family. Tech, therefore, awards financial aid according to individual need and college costs. Students may receive assistance through scholarships, grants, loans, employment, or a combination of these programs. Of course, the student should help to defray expenses through summer or part-time jobs at Tech or in the Atlanta area. Georgia Tech's Placement Center attempts to keep an up-to-date listing of employment opportunities and can provide more information for interested students. In addition, the Cooperative Program, which is not formally a financial aid program, allows approximately one-fifth of the undergraduate enrollment in the fields of engineering, science, and management to pay part of their college expenses by earning $6,000 to $8,000 per year. Financial need is not a prerequisite for consideration in the co-op plan. Co-op participants are considered for financial aid based upon the same analysis used for other students. Students desiring more information on the Cooperative Program should contact the Director of the

Cooperative Division, Georgia Institute of Technology, Atlanta, Georgia 30332-0260.

Students applying for financial aid should file their applications for admission to Georgia Tech by February 1 preceding the fall or summer they expect to enroll. The applicant must receive notice of acceptance no later than March 1 to be eligible for full financial aid consideration.

All entering students, including transfer students, who are interested in scholarships, grants, loans, or work opportunities for any quarter of the academic year beginning in September should submit a Georgia Tech financial aid application before March 1 and a Financial Aid Form to the College Scholarship Service during the month of January. Entering students usually receive financial aid awards by May 1.

For additional information and the *Guide to Scholarships and Financial Aid*, please contact the Director of Scholarships and Financial Aid, Georgia Institute of Technology, Atlanta, Georgia 30332-0460.

Medals and Prizes

Fraternities, academic schools and departments, professional groups, and community organizations award medals and prizes, such as the Phi Kappa Phi Award, and present them at the annual Honors Day exercises or at the term's end.

Graduate Information

Costs (1987-88 Academic Year)	Resident of Georgia	Nonresident of Georgia
Quarterly Fees		
Matriculation	$506	$506
Nonresidence	$ 0	$1,235
Transportation	$ 9	$ 9
Student Activity	$ 30	$ 30
Health Service	$ 46	$ 46
Athletic	$ 30	$ 30
Total	$621	$1,856
Total per year (3 quarters)	$1,863	$5,568

Special courses may require an additional fee.

Graduate students carrying a full academic load (twelve credit hours or more per quarter) must pay the full amount of all fees as shown above.

Part-time students who are carrying between six and eleven credit hours per quarter and who are legal residents of Georgia must pay $36 per credit hour in satisfaction of the matriculation fee and $96 for the athletic, student activity, and medical fees. Students carrying less than six credit hours pay only the matriculation fee. All nonresident part-time graduate students will have an additional tuition fee of $88 per credit hour. A student must enroll for a minimum of three hours. All students must pay the $9 transportation fee.

Note: Conditions may arise beyond the control of the Georgia Institute of Technology that will cause the rate for tuition and fees to be changed during the next year without notice.

Other Fees

Each student petitioning for graduation must pay a $25 graduation fee upon submitting the petition. Students must pay this fee each time they submit a petition for graduation. A candidate for the doctoral degree must pay a charge of $40 for microfilming the dissertation and depositing it with the University Microfilms Service. The Institute assumes the cost of binding the three library copies of a student's thesis or dissertation.

Students who register after the scheduled date must pay a late registration fee. If a date must pay a late registration fee. If a

student has not paid all fees by the end of the first week of the quarter, the Institute will cancel the registration.

Refund of Fees

The Institute has an established set of rules governing the refund of fees to students who must drop out of school (see page 55).

Obligations of Students

An individual is not officially enrolled at Georgia Tech until all transportation, tuition, matriculation, student activity, and medical fees for the current quarter are paid. Once enrolled, every student is obligated to remit, return, or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures that may be taken pursuant to the Student Conduct Code, page 287 ("Student Rules and Regulations").

Graduate Financial Assistance

The Institute offers financial aid from a variety of sources to assist students with the pursuit and completion of their degrees as rapidly as circumstances permit. Some of these are briefly described here. A brochure, *Graduate Student Financial Assistance*, is also available from the Office of Graduate Studies and Research.

Students should address inquiries for financial aid to the director of the school in which they plan to study.

President's Fellowships

Each year the Institute awards fellowships to supplement other awards to matriculants with outstanding academic records and high research potential. Applicants for doctoral degrees receive most of these awards. The fellowship supplement consists of a $4,000 stipend plus tuition and fees for four quarters. These fellowships are renewable for three additional years, based on the major school's evaluation and recommendation.

President's Minority Fellowships

These fellowships are supplementary awards to minority matriculants with outstanding academic records and high research potential. Applicants for doctoral degrees receive most of these awards. The fellowship supplement consists of a $4,000 stipend plus tuition and fees for four quarters. These fellowships are renewable for three additional years based on the major school's evaluation and recommendation.

Graduate Research Assistantships

Students ordinarily receive these awards on a one-third or half-time basis; however, schools, departments, and centers or divisions of the Georgia Tech Research Institute may offer awards of a greater or lesser amount according to their specific needs.

Graduate Teaching Assistantships

Schools and departments ordinarily offer these awards on a one-third or half-time basis, but may choose to give awards of a greater or lesser amount according to their needs.

Federal Fellowships and Traineeships

The Institute participates in a number of fellowship and traineeship programs sponsored by agencies of the federal government.

In addition, the following traineeships associated with specific training programs are available: water resources planning and management through the Environmental Resources Center, radiation health specialist training program through the School of Mechanical Engineering's Nuclear Engineering Program, air quality control through the School of Chemical Engineering, and minerals and mining through the School of Materials Engineering.

Tuition Waivers

Nonresident graduate students who hold research and teaching assistantships on at least a one-third-time basis may register upon payment of resident fees. In addition,

school directors may recommend to the graduate office a limited number of academically outstanding nonresident full-time students for tuition waivers.

Local Industry Work-Study Programs

Many industries located in and around Atlanta offer opportunities to pursue graduate degrees as an integral part of their employee training programs. In such a plan, the student may work and study on a reduced work week schedule that is compatible with school, student, and company requirements. Additionally, the company may choose to pay academic fees, costs of texts, and a supply allowance.

Veterans Program

Veterans may be eligible to receive educational assistance through the Veterans Administration while enrolled and pursuing an approved program of education or training if they were discharged after January 31, 1955, under conditions other than dishonorable from a continuous period of active duty of 181 days or more. If the period was less than 181 days, a veteran may be eligible if the discharge was for service-connected disability.

The VA provides educational assistance to children of veterans who died or are permanently and totally disabled as the result of service-connected disability incurred or aggravated during active service in the Armed Forces, or children of individuals on active duty who are listed for more than ninety days as missing in action, captured by a hostile force, or forcibly interned by a foreign government or power.

The Financial Aid Office at Georgia Tech serves as the veterans affairs center on campus and provides enrollment certification to the Veterans Administration for eligible students. New students and enrolled students wishing to be recertified should make application to the financial aid office at least six weeks prior to the planned quarter of enrollment if they wish to receive the first benefit check for use in registration. For more information, contact the financial aid office at Georgia Tech.

Sponsored Fellowships

The Institute awards a number of fellowships sponsored by various industrial organizations, foundations, and trust funds for the support of outstanding graduate students. These fellowships assist students in pursuing their studies and research full time. Most of these fellowships are restricted to specific areas of study, and interested students should contact the director of the school in which they plan to study.

Fellowships and loans that are not restricted to specific schools include the following.

Domenica Rea D'Onofrio Fellowship
The recipient, who must be from Italy, receives a stipend of $5,000.

Mary White Staton Fellowship
The recipient, who must be from Colombia, South America, receives a stipend of $2,000.

National Consortium for Graduate Degrees for Minorities in Engineering Fellowship
Candidates for participation in this program are selected from minorities (Black Americans, Puerto Ricans, American Indians, and Chicanos). At the time of application, the student should be enrolled in the junior year of undergraduate study in one of the engineering disciplines. In addition to the graduate stipend, this program provides an opportunity for summer work experience in one of several off-campus research laboratories. An applicant's record must indicate the ability to pursue graduate studies in engineering. Some students who are presently in their senior year of undergraduate study may be accepted into the program. For further information, write to the College of Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0360.

Regents' Opportunity Scholarship
The recipients, who must be economically disadvantaged residents of Georgia, receive an award of $5,000 for the academic year.

United States Steel Foundation Loan Fund
This short-term loan fund is designated to assist graduate students in engineering, physics, chemistry, and mathematics and is administered by the financial aid office.

General Electric Foundation Forgivable Loan Fund
Forgivable loans are available to doctoral candidates in engineering and computer science. Students must be United States citizens who plan to pursue an academic career. This loan is forgivable based on years of service in an academic position after receiving the doctoral degree.

This catalog lists alphabetically by colleges the specific degree requirements and course descriptions for each curriculum and course at both the undergraduate and graduate levels.

Course numbers below 1000 denote remedial courses and may not be used in satisfying degree requirements. Course numbers below 3000 indicate lower division (freshman and sophomore) courses. Those numbered 3000-4999 denote upper division (junior and senior) courses, open to students of the lower and upper divisions with the proper prerequisites and to graduate students on approval of the individual student's major school. Courses designed for graduate students are numbered 6000 and above; the methods of presentation and quality of work expected make them generally unsuited to undergraduate participation. An upper-division undergraduate student who has an overall grade point average of 2.7 or higher may therefore enroll in a graduate-level course only after consultation with and approval of his or her major school and the dean of the graduate division.

Figures entered beside the course number and title of each course signify the number of class hours per week, the number of laboratory hours per week, and the quarter hour credit earned for the completed course, in that order. Thus, the entry 4-3-5 in CHEM 1101 means that the course meets for four lecture hours per week and three hours of laboratory per week, and that the student earns five quarter hours credit upon satisfactorily completing the course.

Handicapped Accommodation
In order to provide reasonable accommodation to physically handicapped students who are otherwise qualified, consideration by individual colleges, schools, and departments of instruction may be given to the substitution or modification of certain course requirements—within the limitations imposed by the accreditation criteria for the degree program in which the student is enrolled—and to the extent that such substitutions or modifications of the course or curriculum do not have a net effect of detracting from the quality of the educational experience implied by the course or curriculum designation.

Such substitutions or modifications must be approved by the school director, department head, or college dean, and the Undergraduate Curriculum Committee and/or the Graduate Committee.

College established in 1975, School in 1948, Department in 1908

Dean—William L. Fash; *Associate Dean*—John A. Kelly; *Assistant Dean*—Arthur F. Beckum, Jr.; *Regents' Professors*—Geoffrey G. Eichholz, John A. Templer; *Professors*—Richard M. Aynsley, Alan H. Balfour, Arthur F. Beckum, Jr., Clifford R. Bragdon, Arnall T. Connell, Dale A. Durfee, William L. Fash, Rufus R. Hughes II, John A. Kelly, Richard J. L. Martin, Elliott A. Pavlos, Roger F. Rupnow, David S. Sawicki, Robert T. Segrest; *Associate Professors*—James M. Akridge, Douglas C. Allen, Stanley C. Bailey, Neill W. Connah, Robert M. Craig, Richard Dagenhart, Thomas N. Debo, Garvin T. Dreger, Marco Frascari, John D. Gilleard, Edward L. Keating, Lewis F. Lanter, Pascal Malassigne, James W. Mount, C. Lee Payne, H. Randall Roark, Catherine B. Ross, Bahran Shirdel, C. Virgil Smith, Joan Templer, Jean D. Wineman, Craig M. Zimring; *Assistant Professors*—W. J. Blane, Mitchell A. Bring, John P. Cleaveland, Harris H. Dimitropoulos, Elizabeth M. Dowling, Michael L. P. Elliott, George B. Johnston, Glenn E. Lewis, Thomas E. Papageorge, W. R. Peter Pittman, Clyde D. Robbins, William H. Russell, Albert H. Smith, James P. Williamson; *Instructors*—Jennifer Bloomer, Arthur Chen, Betty Rose Connell, Lane Duncan, Benjamin Erlitz, Michael Jones, David Lewis, Rob Miller, Franklin K. Mooney, Joseph de Casseres Reshower, Molly F. Story, Morris J. Ward, Janice Wittschiebe, Jonathan M. Wood; *Adjunct Professor*—Raymond F. Stainback; *Visiting Professors*—Joseph N. Smith; *Research Engineer*—Anatoliusz Lesniewski; *Research Associate*—Roger Weed; *Research Scientists*—Edwin Boeckler, Tony Bradshaw, Sarah Endicott, Cabell Heyward John Myers, Nathaniel Pugh, Jon A. Sanford.

General Information

The College of Architecture, established in 1908 as the Department of Architecture, became the School of Architecture in April 1948 when the Georgia School of Technology became the Georgia Institute of Technology. The School became the College of Architecture on July 1, 1975.

The original four-year curriculum led to the degree Bachelor of Science in Architecture. In 1934, this curriculum expanded to a five-year program awarding the degree Bachelor of Architecture, which was offered as a first professional degree until 1972. The four-year degrees, Bachelor of Science in Building Construction and Bachelor of Science in Industrial Design, were established in 1958 following a period during which the curricula in these disciplines functioned as options under architecture.

In 1952, the College initiated the Master of Architecture and Master of City Planning degrees; a joint degree program with the simultaneous award of both degrees has been in operation since 1969. Two-year joint degree programs between city planning and civil engineering (transportation), city planning and urban design, and city planning and environmental design (landscape architecture) at the University of Georgia are currently available.

The original aim and prime objective of the College is to prepare students for the profession of architecture. The scope of human concern with the environment is of such breadth in current practice, however, that architects and planners not only must demonstrate strength in the traditional role of building and space design but also must re-emphasize related interests in the social sciences and psychology, structural and mechanical systems, management of construction and field processes, and economic feasibility programming. Graduates with such grounding contribute effectively to teams that create and control the constructed environment at every scale, from the production of the smallest utilitarian object to community, city, and regional planning. It is to this end that, over the years, the College of Architecture has embraced as many disciplines in design and planning as possible, not only to educate its students in specialized environmental fields, but also to liberalize and expand the education through their interaction.

Recent changes in the content of all curricula take precedence over the listings in earlier catalogs.

Undergraduate Programs

Architecture

The undergraduate curriculum in architecture prepares the student through basic professional studies and general education to receive the degree Bachelor of Science (undesignated) at the end of four years. This is not a professional degree in architecture and will not be recognized as such by the National Architectural Accrediting Board and the National Council of Architectural Registration Boards; professional degree accreditation applies only to the degree Master of Architecture, awarded after two years of graduate study.

For architecture majors, averages in architectural design will be checked at the end of each year-group of three courses (ARCH 1001-2-3, etc.). The College will not permit a student to enter a more advanced group until his or her record in the previous group averages 2.0 or better. Also, a grade of C or better must be achieved in each of ARCH 4001, 4002, and 4003 to qualify a student for a B.S. degree. All work executed in the College becomes the property of the College and will be retained or returned at the discretion of the faculty. The faculty also reserves the right to refuse for credit any project executed outside the precincts of the College or otherwise executed without proper coordination with the instructor.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 1001-2-3 Design Fundamentals	1-12-5	1-12-5	1-12-5
ARCH 1201-2-3 Architectural History	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Mathematics	5-0-5	5-0-5	5-0-5
Physical Education (requirements, p. 253)	.....	.....	3-0-3
Electives	3-0-3	3-0-3	3-0-3
TOTALS	12-12-16	12-12-16	15-12-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 2001-2-3 Architectural Design	1-12-5	1-12-5	1-12-5
ARCH 2304 Building Systems I	3-0-3	.....	.....
ARCH 2305 Man, Climate, and Buildings	.....	3-0-3	.....
ARCH 2306 Architectural and Mechanical Systems	.....	.....	3-0-3
PHYS 2111-2-3 Elementary Physics	4-0-4	4-0-4	4-0-4
ESM 3701-2 Statics, Mechanics of Materials	.....	3-0-3	3-0-3
Electives	6-0-6	3-0-3	3-0-3
TOTALS	14-12-18	14-12-18	14-12-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 3001-2-3 Architectural Design	1-12-5	1-12-5	1-12-5
ARCH 3301 Acoustics and Lighting	.....	3-0-3	.....
ARCH 3321-2-3 Structures and Materials	4-3-5	4-3-5	4-3-5
ARCH 3401-41 Urban Planning, Building Economics	3-0-3	.....	3-0-3
Electives	3-0-3	3-0-3	3-0-3
TOTALS	11-15-16	11-15-16	11-15-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 4001-2-3 Architectural Design	1-12-5	1-12-5	1-12-5
Electives	12-0-12	12-0-12	12-0-12
TOTALS	13-12-17	13-12-17	13-12-17

ELECTIVES

Sixty-six elective hours are included in the undergraduate architecture curriculum. With the advice of faculty counselors, electives should be selected to include the categories listed below. These categories will satisfy the core curriculum requirements of the College of Architecture in the humanities and social sciences, will cover additional professional requirements of the curriculum in architecture, and will allow a degree of latitude for the student to plan toward concentrated study in the graduate program.

Humanities Electives

Nine credit hours are to be devoted to English literature courses or to appropriate modern languages courses at the 3000 level or above. Note that the required architectural history sequence, ARCH 1201-2-3, satisfies the remaining nine hours of humanities requirements.

Social Sciences Electives

Eighteen credit hours are required, including at least three hours in each of sociology, political science, psychology, and history. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

General Electives

Thirty-nine credit hours may be structured to best further the student's professional goals but must include at least six credit hours of advanced architectural history and six credit hours in visual communication studio courses. Military training is an optional program of the Institute, but if basic ROTC and advanced military are elected, no more than fifteen credit hours of free electives may be used for this purpose or will be credited toward the requirements for a degree.

The College of Architecture will accept only the three required hours of physical education toward meeting the requirement for a degree.

Only twelve hours of free electives taken on a pass/fail basis may be applied toward fulfilling requirements for the B.S. degree. MATH 1709 will not count toward fulfilling any of the degree requirements.

Senior Year Study Abroad Program

The College of Architecture Study Abroad Program is designed to give senior students in architecture the opportunity to complete all or part of their senior year in residence, Paris, France. The program offers courses paralleling those in the regular program, as well as specialized opportunities for travel and individual study interests. Students participating in the program are registered in Ecole des Beaux Arts and live in housing arranged by the Institute. While Georgia Tech faculty conduct the courses, faculty of the Ecole des Beaux Arts also participate periodically with the program.

To provide better preparation for living, studying, and traveling in Europe, students should enroll in French language and culture courses at Georgia Tech prior to their senior year.

Building Construction

In tandem with the architect and engineer, the constructor is an equal partner in a complexity of integrated professional disciplines responsible for the physical reality of the habitable structures in the built environment. Building construction education is a unique academic discipline with increasing demands for innovation, research, and leadership preparation. The building construction degree program is structured to accommodate contemporary and future industry directions with the objective of providing an innovative and forward-looking educational experience to prepare participants for entry and advancement into leadership roles in major segments of the dynamic industry.

Three formal degree options are offered that provide individual concentrations of study in three major disciplines in the industry: (1) management, (2) development, and (3) science. Students select an option that is compatible with their interests and career objectives. The three options include a foundation core of study in construction technology and practice, physical sciences and mathematics, and humanities and social sciences. Each total curriculum combines technical and liberal arts elements into a synergistic building sequence, which culminates in the senior year with the development and presentation of a comprehensive terminal project that serves as the core evaluation of the student's overall educational experience in building construction.

Option 1—Construction Management

The construction management curriculum provides students the opportunity to pursue specialized study and develop skills in managerial systems and practices utilized by constructors to manage the planning and delivery processes of buildings in the contemporary practice of construction.

Managerial areas of study range from internal management systems used by general contractors and builders in office operations and practice to management and systems controls employed by construction managers in the planning, design, and construction phases of complex building projects. Studies in construction management coupled with the strong educational base in construction technology and practice prepare students for fulfilling careers in the fields of general contracting, specialty contracting, construction consulting, and construction management.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 1201-2-3 Architectural History	3-0-3	3-0-3	3-0-3
BC 1010 Building Construction Seminar	.....	.....	1-0-1
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
GEOS 2100-2 General Geology	.....	.....	3-3-4
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Physical Education (requirements p. 253)	.....	.....	3-0-3
Electives	.....	.....	3-0-3
TOTALS	15-3-16	15-3-16	18-3-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 2304 Building Systems I	3-0-3	.....	.....
ARCH 2305 Man, Climate, and Buildings	.....	3-0-3	.....
ARCH 2306 Architectural and Mechanical Systems	.....	.....	3-0-3
BC 2010 Construction Technology I	3-6-5	.....	.....
BC 2020 Construction Technology II	.....	3-6-5	.....
BC 2020 Construction Cost Engineering	.....	.....	2-9-5
MGT 2000 Accounting I	.....	3-0-3	.....
PHYS 2111-2-3 Elementary Physics	4-0-4	4-0-4	4-0-4
ESM 3701-2 Statics, Strength of Materials	.....	3-0-3	3-0-3
MSCI 2000 Management Applications of Data Processing	3-0-3	.....	.....
ECON 2000 Principles of Economics I	3-0-3	.....	.....
Electives	.....	.....	3-0-3
TOTALS	16-6-18	16-6-18	15-9-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 3321-2-3 Structure and Materials I, II, III	4-3-5	4-3-5	4-3-5
ARCH 3441 Building Economics	.....	.....	3-0-3
BC 3310 Construction Contracting	3-0-3	.....	.....

BC 3320 Construction Law	.....	3-0-3	.....
BC 3330 Real Estate and Construction Finance	.....	.....	3-0-3
MGT 3050 Computer-based Management Systems	.....	.....	3-0-3
MGT 3150 Management Theory	.....	3-0-3	.....
MGT 3260 Business Law	3-0-3	.....	.....
ENGL 3015 Public Speaking	.....	3-0-3	.....
ENGL 3020 Technical Writing	3-0-3	.....	.....
Electives	3-0-3	3-0-3	3-0-3
TOTALS	16-3-17	16-6-17	16-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
BC 4500-10 Terminal Project I, II	.....	3-0-3	1-12-5
BC 4440 Construction Scheduling	3-6-5	.....	.....
BC 4442 Value Engineering in Construction	.....	3-0-3	.....
BC 4450 Building Production	3-0-3	.....	.....
BC 4460 Risk Management	.....	3-0-3	.....
MGT 4100 Organizational Analysis	3-0-3	.....	.....
MGT 4200 Industrial Relations	.....	3-0-3	.....
PSY 4401 Industrial Psychology	.....	3-0-3	.....
Electives	6-0-6	6-0-6	6-0-6
TOTALS	15-6-17	18-0-18	10-12-14

Option 2—Construction Development

The construction development curriculum introduces students to entreprenerial theories and practices used in the development of construction projects ranging from single facilities to multiple-building complexes. This concentration of specialized study focuses on urban economic theories, planning legislation and regulation, and urban development methods applicable in land and real estate investment. Emphasis is on the development and marketing theories of building projects in the context of contemporary planning and urban development issues. The core curriculum requirements in construction technology and practice combined with building investment and development theories provide a broad educational foundation for rewarding career opportunities in the entrepreneurial development areas of the construction industry.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 1202-2-3 Architectural History	3-0-3	3-0-3	3-0-3
BC 1010 Building Construction Seminar	.....	.....	1-0-1
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
GEOS 2100-2 General Geology	.....	.....	3-3-4
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Physical Education (requirements, p. 253)	.....	.....	3-0-3
Electives	.....	.....	3-0-3
TOTALS	15-3-16	15-3-16	18-3-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 2304 Building Systems I	3-0-3	.....	.....
ARCH 2305 Man, Climate, and Buildings	.....	3-0-3	.....
ARCH 2306 Architectural and Mechanical Systems	.....	.....	3-0-3
BC 2010 Construction Technology I	3-6-5	.....	.....
BC 2020 Construction Technology II	.....	3-6-5	.....
BC 2030 Construction Cost Estimating	.....	.....	2-9-5
MGT 2000 Accounting I	.....	3-0-3	.....
PHYS 2111-2-3 Elementary Physics	4-0-4	4-0-4	4-0-4
ESM 3701-2 Statics, Mechanics of Materials	.....	3-0-3	3-0-3
MSCI 2000 Management Applications of Data Processing	3-0-3	.....	.....
ECON 2000 Principles of Economics I	3-0-3	.....	.....
Electives	.....	.....	3-0-3
TOTALS	16-6-18	16-6-18	15-9-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 3321-2-3 Structures and Materials I, II, III	4-3-5	4-3-5	4-3-5
ARCH 3441 Building Economics	.....	.....	3-0-3
BC 3310 Construction Contracting	3-0-3	.....	.....
BC 3320 Construction Law	.....	3-0-3	.....
BC 3330 Real Estate and Construction Finance	.....	.....	3-0-3
MGT 3060 Finance I	.....	3-0-3	.....
MGT 3070 Management Science Models in Finance	.....	.....	3-0-3
MGT 3260 Business Law	3-0-3	.....	.....
ENGL 3015 Public Speaking	.....	3-0-3	.....
ENGL 3020 Technical Writing	3-0-3	.....	.....
Electives	3-0-3	3-0-3	3-0-3
TOTALS	16-3-17	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
BC 4500-10 Terminal Project I,II	.....	3-0-3	1-12-5
BC 4440 Construction Scheduling	3-6-5	.....	.....
BC 4442 Value Engineering in Construction	.....	3-0-3	.....
BC 4450 Building Production	3-0-3	.....	.....
BC 4460 Risk Management	.....	3-0-3	.....
CP 4402 Contemporary Planning and Development Issues	.....	3-0-3	.....
CP 4441 The Political Economy of Urban Development	.....	3-0-3	.....
CP 4442 Introduction to Real Estate Investment and Development	3-0-3	.....	.....
Electives	6-0-6	3-0-3	9-0-9
TOTALS	15-6-17	18-0-18	10-12-14

Option 3—Construction Science

The construction science curriculum is an analytically oriented course of study designed to encourage students to challenge current methods of building construction and delivery techniques and to seek innovative solutions through study, research, and technical inquiry. Emphasis is on the means and methods of constructing buildings, the intrinsic nature and use of construction materials, the anatomy of building systems and components, and prefabricated building systems and components development and production concepts. Graduates are prepared to enter and advance in the construction industry in the mangement and production areas of general contracting, specialty contracting, specialty consulting, the pre-engineered building systems and components industry, and the construction materials and equipment industry. The construction science option provides an outstanding undergraduate foundation leading to graduate study and research in the building construction field.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 1201-2-3 Architectural History	3-0-3	3-0-3	3-0-3

Course	1st Q.	2nd Q.	3rd Q.
BC 1010 Building Construction Seminar	.....	.....	1-0-1
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
GEOS 2100-2 General Geology	.....	.....	3-3-4
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Physical Education (requirements, p. 253)	.....	.....	3-0-3
Electives	.....	.....	3-0-3
TOTALS	15-3-16	15-3-16	18-3-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 2304 Building Systems I	3-0-3	.....	.....
ARCH 2305 Man, Climate, and Buildings	.....	3-0-3	.....
ARCH 2306 Architectural and Mechanical Systems	.....	.....	3-0-3
BC 2010 Construction Technology I	3-6-5	.....	.....
BC 2020 Construction Technology II	.....	3-6-5	.....
BC 2030 Construction Cost Estimating	.....	.....	2-9-5
MGT 2000 Accounting I	3-0-3	.....	.....
MATH 2307 Calculus IV	5-0-5	.....	.....
PHYS 2121-2 Particle Dynamics, Electromagnetism	.....	4-3-5	4-3-5
ESM 3701-2 Statics, Mechanics of Materials	.....	3-0-3	3-0-3
ECON 2000 Principles of Economics I	3-0-3	.....	.....
Electives	.....	.....	3-0-3
TOTALS	17-6-19	13-9-16	15-12-19

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 3321-2-3 Structure and Materials I, II, III	4-3-5	4-3-5	4-3-5
ARCH 3441 Building Economics	.....	.....	3-0-3
BC 3310 Construction Contracting	3-0-3	.....	.....
BC 3320 Construction Law	.....	3-0-3	.....
BC 3330 Real Estate and Construction Finance	.....	.....	3-0-3
PHYS 2123 Optics and Modern Physics	4-3-5	.....	.....
CE 3513 Applications of Digital Computers	3-0-3	.....	.....
CE 3309 Materials of Construction	.....	3-3-4	.....
ENGL 3015 Public Speaking	.....	.....	3-0-3
ENGL 3020 Technical Writing	.....	3-0-3	.....
Electives	3-0-3	3-0-3	3-0-3
TOTALS	17-6-19	16-6-18	16-3-1?

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
BC 4500-10 Terminal Project I, II	.....	3-0-3	1-12-5
BC 4301 Construction Systems	3-0-3	.....	.....
BC 4440 Construction Scheduling	3-6-5	.....	.....
BC 4442 Value Engineering in Construction	.....	3-0-3	.....
BC 4450 Building Production	3-0-3	.....	.....
BC 4460 Risk Management	.....	3-0-3	.....
ISYE 3231 Deterministic Operations Research	3-0-3	.....	.....
Electives	3-0-3	6-0-6	9-0-9
TOTALS	15-6-17	15-0-15	10-12-14

ELECTIVES

A total of thirty-three hours of electives are included in each curriculum in building construction, and with the advice of faculty counselors, electives should be selected to include the categories listed below. These categories will satisfy the core curriculum requirements of the College of Architecture in the humanities and social sciences and the additional professional requirements of the building construction program.

Humanities Electives

Eighteen credit hours are required. The required architectural history sequence, ARCH 1201-2-3, and the required English sequence, ENGL 1001-2, will satisfy fifteen hours. The remaining three hours are selected by the student.

Social Sciences Electives

Eighteen credit hours of social sciences are required, including one course in sociology, political science, history, psychology, or philosophy. Note that ECON 2000 will satisfy three hours of social sciences requirements. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

General Electives

Fifteen hours are required. Nine credit hours of professional electives are required at the 3000 level or above as approved by the department. Three hours of professional elective credit may be satisfied on a pass/fail basis for summer intern employment in the construction industry with departmental consent and approval. Six hours of free electives are required to fulfill the requirement for the B.S.B.C. degree; these electives may be taken on a pass/fail basis. Military training is an option of the Institute. If basic ROTC is elected, six credit hours of free electives may be used. If advanced military training is elected, nine credit hours of professional hours for this purpose will be credited toward meeting degree requirements.

The College of Architecture will accept only the three required hours of physical education toward meeting degree requirements. MATH 1709 will not count toward fulfilling any of the degree requirements.

Industrial Design

Industrial design is the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer. Industrial designers, with their wide range of interests and generalist outlook in an age of specialization, must be part artist, part entrepreneur, and part engineer.

The industrial designer's work touches all of our lives in the form of home furnishings, transportation, appliances, recreational equipment, and a myriad of other consumer and industrial products and services. While giving form to the efforts of industry, the designer is at the same time a consumer advocate, providing the humanizing link between technology and the consumer.

The Georgia Tech program offers a well-rounded course of study with early emphasis on basic design. Projects stress realistic design situations; the program encourages students to develop a diverse background in order to expand individual talents and respond to changing opportunities in the field. Most faculty members are practicing designers with extensive experience in the field.

Grade averages in design courses are checked at the end of each year-group of three courses (ID 2001-2-3, etc.). A student may not enter a more advanced group until his or her record in the previous group equals 2.0 or better. All work executed in the College becomes the property of the College and will be retained or returned at the discretion of the faculty. The faculty also reserves the right to refuse credit for any project executed outside the precincts of the College or otherwise executed without proper coordination with the instructor.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ARCH 1001-2-3 Design Fundamentals	1-12-5	1-12-5	1-12-5

MATH 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5

ENGL 1001-2			
Analysis of Literature and Language I, II	3-0-3	3-0-3	.....

ENGL 2XXX			
English Elective	.....	.....	3-0-3

ARCH 4247-8-9			
History of Art I, II, III			

or

ARCH 1201-2-3			
History of Architecture I, II, III	3-0-3	3-0-3	3-0-3

Physical Education			
(requirements, p. 253)	.....	.....	3-0-3
TOTALS	12-12-16	12-12-6	15-12-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ID 2001-2-3			
Industrial Design	1-12-5	1-12-5	1-12-5
ID 2301-2			
Materials and Processes	1-3-2	1-3-2	.....
ID 1263			
History of Industrial Design	.....	.....	3-0-3
Visual Communications Elective (Drawing)	.....	.....	0-6-2
PHYS 2111-2-3			
Elementary Physics	4-0-4	4-0-4	4-0-4
ESM 3701-2			
Statics, Strength of Materials	.....	3-0-3	3-0-3
ECON 2000			
Microeconomics	.....	3-0-3	.....
History or Philosophy of Science and Technology Elective: HIST 1028, 3015, 3016, 3030, 3047-8-9, 4008, 4016, or PST 1127	3-0-3	.....	.....
Sociology Elective	3-0-3	.....	.....
TOTALS	12-15-17	12-15-17	11-18-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ID 3001-2-3			
Industrial Design	1-12-5	1-12-5	1-12-5

ID 3301-2-3			
Materials and Processes	1-3-2	1-3-2	1-3-2
PSY 3303			
General Psychology I	3-0-3	.....	.....
Visual Communications Elective (Photography)	0-6-2	.....	.....
Human Factors Elective ARCH 4751, ISYE 3010, 3113, 3115, PSY 4409, 4751 or 4756	.....	3-0-3	3-0-3
Social Sciences Elective	.....	3-0-3	3-0-3
English or Modern Languages Electives	3-0-3	3-0-3	3-0-3
Visual Communications Elective	.....	.....	2-0-2
Elective	2-0-2	.....	.....
TOTALS	8-21-17	11-15-16	13-15-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ID 4101			
Industrial Design I	1-12-5	.....	.....
ID 4002-3			
Industrial Design II, III	.....	1-18-8	1-18-8
ID 4451			
Professional Practice of Industrial Design	3-0-3	.....	.....
MGT 3300			
Marketing	3-0-3	.....	.....
Management Elective	3-0-3	.....	.....
Electives	3-0-3	9-0-9	9-0-9
TOTALS	13-12-17	10-18-17	10-18-17

ELECTIVES

History of Art or History of Architecture Elective
Students may choose courses in either sequence but must choose one course in each time period (I, II, and III).

Social Sciences Electives
All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

General and Technical Electives

Eleven free elective hours may include six hours credit for basic ROTC courses; twelve technical elective hours are to be chosen from the College's list and may include nine hours of advanced ROTC. Those enrolling in ROTC must schedule appropriate ROTC courses in the freshman and sophomore years.

The College of Architecture will accept only the three required hours of physical education toward meeting the requirements for a degree. Twelve hours of only free electives taken on pass/fail basis may be applied toward fulfilling requirements for the B.S.I.D. degree. MATH 1709 will not count toward fulfilling any of the degree requirements.

Graduate Programs

Architecture

The graduate architecture program leads to the professional Master of Architecture degree, accredited by the National Architectural Accrediting Board. The program aims to be responsive to significant shifts taking place in both the discipline and in the profession. Its major objectives are to offer thorough knowledge of the significant skills, theories, and methods related to the design and production of architecture and to ensure that there is a direct relationship between stated beliefs and actions; to engage the leading questions of the time in whatever aspect of architecture is chosen; and to allow an individual to construct a program of study unique to his or her ability and desire for understanding.

The program has four areas of study: theories and methods in architecture; urban design and development; environment and behavior; and architectural technology. Students have the option of concentrating study in a particular area or of constructing a concentration with approval to suit individual needs and backgrounds. The College offers a joint degree program in urban design and city planning. Students completing this program receive both the Master of Architecture and the Master of City Planning degrees.

Programs of study between architecture and other related fields, e.g., management, can be written. These programs, after approval by the faculty, can lead to other joint degrees. A summer school is held annually in London at the Architecture Association School.

The College has established an active architectural research program. Work performed in this program has won international acclaim in several areas: accessibility for the pedestrian and the handicapped, postoccupancy evaluation, and studies of energy related to buildings. To a limited degree, special projects can be arranged within the research program for credit, and a limited number of research assistantships are available each year. The College is also the center for the National Park Service Management Inventory Program in which all buildings administered by the Park Service are being documented.

There are three different curricula arrangements:
a) The Two-year Program for those holding a four-year bachelor's degree with a major in architecture.
b) The Extended Degree for those holding degrees in fields other than architecture.
c) The One-year Program for those holding either a bachelor's degree in architecture from a five-year accredited program or for those holding a master's degree in architecture who wish to do specialized postgraduate study.

The Two-year Program
The program is structured for persons holding a four-year degree with a major in architecture from a school offering an accredited professional degree in architecture. Students having appropriate concentration in architecture in their undergraduate studies can expect to complete this program in two years. A minimum concentration study program has the following requirements:

Concentration course credits 12
Concentration studio credits 12
Thesis credits 18
Additional required courses 12
Electives 36
Total 90

Extended Degree Program

Students admitted to the extended degree program in architecture follow a special basic program for approximately two years. The program is composed of course work in architectural design, architectural history, planning, mechanics, structures, and building components. In the last two years, these students join graduate students who hold an undergraduate degree in architecture.

The previous course of study is taken into account in developing an individual's program. The program assumes that a student's undergraduate work has included a year of calculus for engineers and a year of physics.

The One-year Program

Persons holding a first professional degree in architecture (Bachelor of Architecture, Master of Architecture, or equivalent) from an accredited school of architecture usually finish the program during one academic year (fifty credit hours). As with the two-year program, the course work is developed within the major study areas outlined above.

City Planning

The graduate program in city planning educates those students whose ultimate goal is the creation of more livable urban environments. Founded in 1951, it is one of the oldest professional planning programs in the United States, with nearly five hundred alumni. Graduates are employed in both the public and private sectors, at all levels of government, by banks, real estate and development companies, utilities, and private corporations. The program is fully recognized by the American Institute of Certified Planners.

Approximately half of the program consists of required courses, called the core. The core is composed of three substantive streams: urban, regional, locational, and development economics and policy; planning theory and process, including decision analysis, forecasting, planning and policymaking processes, risk analysis, implementation, and history and theory of the profession itself; and planning methods, including data analysis, mainframe and microcomputing, descriptive and inferential statistics, micro-

economic analytic techniques, modeling, and planning intelligence and information systems.

The core is largely contained within the student's first year; in the second year he or she chooses among several areas of specialization. Examples of these specialties include transportation planning, urban design and physical planning, development planning and real estate, environmental and energy planning, and neighborhood and community development planning.

Two types of degree programs are available for students interested in the fields of urban and regional planning: the two-year professional Master of City Planning degree (recognized by the American Institute of Certified Planners for membership purposes) and the joint programs described below.

The two-year curriculum requires, for most students, five quarters of course work and a seventeen-credit (one quarter) thesis. Students are allowed to substitute four courses in their concentration for the thesis and write a six-credit thesis option paper. An approved internship is required for those students with no previous planning work experience.

The city planning program maintains joint degree programs with three other academic units: urban design in architecture at Georgia Tech, transportation in civil engineering at Georgia Tech, and environmental design in landscape architecture at the University of Georgia. A description illustrating the urban design joint degree program follows. A student can structure his or her program so that required courses taken in one program can serve as elective credit in the other, thus allowing the student to receive two master's degrees in less time than the two would take to complete if pursued separately. In addition to these three joint degree programs, planning maintains communications with the programs in real estate at Georgia State University, where a certificate in real estate can be obtained, and with public administration at the University of Georgia. Programs of study can coordinate offerings in these two areas.

The College offers a joint degree program in urban design as a cooperative effort

between the architecture and city planning programs. Students completing this program receive both the Master of Architecture and the Master of City Planning degrees. The program requires a minimum of one hundred hours (two years) for those who hold the Bachelor of Architecture degree and 134 hours (two and two-thirds years) for those who hold the Bachelor of Science degree in Architecture. Students must be admitted simultaneously to both graduate programs.

Doctoral Program

The Doctor of Philosophy is an advanced degree directed toward proficiency in independent scholarly work in architecture and city planning. The program includes course work in the nature of philosophy of inquiry, additional specialized work in the area of a doctoral dissertation and in one or more other areas, competence in a foreign language, the satisfactory completion of a comprehensive examination, and an independent research dissertation. For further details of the program, contact the Director of the Doctoral Program, College of Architecture, Georgia Institute of Technology, Atlanta, Georgia 30332-0155.

Courses of Instruction

ARCHITECTURE

ARCH 1001-2-3. Design Fundamentals I, II, III
1-12-5 each.
Introductory studies in visual and structural expression emphasizing the processes of problem identification, design method, and communication.

ARCH 1201-2-3. History of Architecture I, II, III
3-0-3 each.
A study of our architectural heritage from the beginning of recorded history to the present day. Open to all freshmen.

ARCH 2001-2-3. Architectural Design I, II, III
1-12-5 each. Prerequisite: ARCH 1003.
Design of simple buildings emphasizing technical subjects in related courses.

ARCH 2304. Building Systems I
3-0-3.
Introduction to building systems, materials, codes, and construction.

ARCH 2305. Man, Climate, and Buildings
3-0-3.
Energy transfer mechanisms and methods for qualifying steady-state thermal transfer with emphasis placed on residential scale buildings.

ARCH 2306. Architectural and Mechanical Systems
3-0-3.
Building energy use and design methods, including solar analysis, transient thermal analysis, thermal comfort, and optimal use of mechanical systems.

ARCH 2361-2. Color Theory I, II
1-3-2 each.
Lecture and laboratory experiments on the properties of color and its use in design.

ARCH 3001-2-3. Architectural Design I, II, III
1-12-5 each. Prerequisites: ARCH 2003, 2303.
Site planning, community and urban design. Design of complex facilities, in association with corequisite courses.

ARCH 3201. History of Ancient Architecture
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.
Historical survey of the architecture of antiquity from prehistoric times through the second century A.D. Emphasizes the architectural traditions of classical antiquity.

ARCH 3202. History of Medieval Architecture
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.
Historical survey of the architecture in Medieval Europe, including the Early Christian, Byzantine, Dark Ages, Romanesque, and Gothic eras.

ARCH 3203. History of Renaissance and Mannerist Architecture
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.
Historical survey of European architecture in the Renaissance and Mannerist periods.

ARCH 3204. History of Baroque and Rococo Architecture
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.
Historical survey of European architecture during the seventeenth and eighteenth centuries.

ARCH 3301 Acoustics and Lighting
3-0-3.
Integration of artificial lighting with building form including computational methods. Investigation of basic theory of architectural acoustics and acoustical design.

ARCH 3321-2-3. Structures and Materials I, II, III
4-3-5. Prerequisites for ARCH 3321: ARCH 2301, ESM 3702; prerequisite for ARCH 3322 and 3323: ARCH 3321.
Wood, masonry, light-steel frames, steel, reinforced concrete, integration of steel and concrete, indeterminant structures. Design, application, specification, and testing of components.

ARCH 3401-41. Urban Planning, Building Economics
3-0-3 each.
Survey and historic background of urban planning in the United States; economics of building development, construction, and operation.

ARCH 3811-2. Special Topics—Visual Communications
0-3-1 each.

Introductory studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 3815-6. Special Topics—Visual Communications
0-6-2 each.

Introductory studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 3911-2-3-4. Special Problems—Visual Communications
0-3-1 to 0-15-5.

Introductory studio work in drawing and painting, sculpture and three-dimensional concepts, photography, and graphic design and rendering.

ARCH 4001. Architectural Design I
1-12-5. Prerequisite: ARCH 3003.

Architectural design synthesizing material presented in previous years.

ARCH 4002-3. Architectural Design II, III
1-12-5 each. Prerequisite: ARCH 4001.

Terminal project. Selection of a facility for design by the individual student, with approval by the faculty. Research and programming for terminal project. Schematic and final design and preparation of design documents.

ARCH 4204. History of Architecture in England I
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture in England from Roman times to 1715. Focus is on cathedrals and on domestic architecture, from castles and fortified manor houses to Tudor, Elizabethan, Jacobean, and Baroque country houses.

ARCH 4205. History of Architecture in England II
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture in England, from Wren to the present, concentrating on the eighteenth and nineteenth centuries.

ARCH 4206. History of Architecture in the United States.
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture in America from colonial times to the present.

ARCH 4207. History of Modern Architecture I: Nineteenth Century
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture in the nineteenth century, focusing upon currents of romanticism, classicism, eclecticism, vernacular styles, and the advances in engineering and building technology.

ARCH 4208. History of Modern Architecture II: 1890 to 1950
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture during the early modern movement. Focuses upon the old masters (Gropius, Wright, Le Corbusier, and Mies van der Rohe) and

introduces modern movements such as Art Nouveau, DiStijl, International Style, and Art Deco.

ARCH 4209. History of Modern Architecture III: 1945 to Present
3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College.

Historical survey of architecture since World War II, focusing upon the influence of the old masters of modern architecture upon architects active after 1945. Introduces trends such as the Miesian Aesthetic, New Formalism and New Brutalism, and Post-Modernism.

ARCH 4210. History of Architecture in France
3-0-3.

Historical survey of architecture in France, from Roman times to present, with particular attention to architecture in and near Paris. Course is especially designed as preparation for Study Abroad Program for architecture student in Paris.

ARCH 4221. Paris: Social, Urban, and Architectural History
3-0-3.

The social, cultural, urban, and architectural history of the city of Paris, from its founding until the beginning of the Second Empire. Course offered in Paris only.

ARCH 4247-8-9. History of Art I, II, III
3-0-3 each.

A survey in the study of artistic manifestations from primitive times to our own day. First quarter of sequence: prehistoric through Roman; second quarter: Early Christian through Baroque; third quarter: nineteenth and twentieth centuries.

ARCH 4304. Energy Flow in a Systems Context
3-0-3. Prerequisite: senior standing or consent of the College.

The study of energy and energy flow in a systems context.

ARCH 4751-2. Psychology of Environmental Design I, II
3-3-4 each. Prerequisite: consent of the College.

Course listing and description found under PSY 4751-2.

ARCH 4811-2. Special Topics—Visual Communications
0-3-1 each.

Intermediate studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 4815-6. Special Topics—Visual Communications
0-6-2 each.

Intermediate studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 4821-2-3. Special Topics in History and Theory
3-0-3 each. Prerequisite: consent of the College.

Topics in advanced areas of history and theory of architecture.

ARCH 4851-2-3. Special Topics
3-0-3 each.

ARCH 4911-2-3-4. Special Problems—Visual Communications
0-3-1 to 0-15-5. Prerequisites: ARCH 3911-2-3-4.

Intermediate studio work in drawing and painting, sculpture and three-dimensional concepts, photography, and graphic design and rendering.

ARCH 4915-6-7-8. Special Problems—Visual Communications
Credit to be arranged. Prerequisite: consent of the College.

Self-directed studies in visual communications arts.

ARCH 4941-2-3-4-5. Special Problems
Credit to be arranged.

ARCH 4951-2-3-4. Special Problems
Credit to be arranged.

ARCH 6012-3. Architectural Design Studio I, II
1-15-6.

Advanced problems in architectural design. Studio exercises focus on the applications, theories of typology, symbolic ordering, and urban structure using advanced methods of visual representation.

ARCH 6022-3. Urban Design Studio I, II
1-15-6.

Applications of urban design and planning theory and methods to design issues in the contemporary city. Emphasis on the integration of knowledge from related course work.

ARCH 6042-3. Architectural Technology Studio I, II
1-15-6.

Investigating the influence on building design of selected subjects in architectural technology. Subjects include building physics, material performance, design process, and construction methods.

ARCH 6062-3. Behavior in Architecture Studio I, II
1-15-6.

Advanced problems in behavior focusing on application of behavioral knowledge to architectural design, moving from general principles to specific applications.

ARCH 6201. Contemporary Theory in Architecture
3-0-3.

Review and critical evaluation of current architectural design theories.

ARCH 6211. Architectural Design Methods
3-0-3.

Examination of processes and methods of architectural design within the framework of science and the arts, including a variety of historical and contemporary positions.

ARCH 6213. Case Studies in Commercial Architecture I
3-0-3.

Case studies of the history, development, and design of selected types of commercial architecture.

ARCH 6214. Case Studies in Commercial Architecture II
3-0-3.

Case studies of the history, development, and design of mixed-use developments in commercial architecture.

ARCH 6221. Urban Design Theory
3-0-3.

Evolution of urban design theory from the Renaissance city to the present, particularly the dialectic of utopian thought and actual historical evidence of city form.

ARCH 6222. Readings in Urban Theory
3-0-3.

Investigations of urban design theory and practice during the nineteenth and twentieth centuries. Emphasis on formal, scientific, social, and economic interpretations of the city.

ARCH 6223. Studies in Landscape Architecture
3-0-3.

History of the design of the landscape and the garden from Ancient Egypt, Persia, and the Orient to the present.

ARCH 6262. Readings in Architectural History
3-0-3.

Presentation and discussion of topics of current interest and specialized scope, utilizing the special resources of the architecture library and current architectural history publications.

ARCH 6263. Housing and Culture
3-0-3.

Anthropological, psychological, and architectural theories of house form and culture.

ARCH 6264. Intentions in Architectural History
3-0-3.

Readings on the meaning of architecture, the nature of architectural history, and the varied interpretations of architecture evidenced in architectural historiography.

ARCH 6341. Energy in Architecture
3-3-4.

An investigation of energy requirements in buildings and the use of interactive computer programs to analyze and minimize energy usage.

ARCH 6342. Building Energy Analysis
3-3-4.

Appropriate techniques, strategies, and methods for predicting and evaluating building energy performance. Lab exercises emphasize the relationship between architectural design decisions and predicted building performance.

ARCH 6351. Advanced Architectural Acoustics
3-0-3.

Design requirements for noise control and acceptable room acoustics. Practical design problems, materials selection, and calculation of sound propagation parameters.

ARCH 6371-2. Computer Programming for Architects I, II
3-0-3 each. Prerequisite: consent of the College.

Development of advanced programming skills emphasizing algorithms of special interest to architects.

ARCH 6401. Landscape Resource Analysis
3-0-3. Prerequisite: graduate standing.

Analysis and design methods for solving large-scale or complex site development problems in both the public and private sectors.

ARCH 6402. Introduction to the Preservation and Conservation of Cultural Resources
3-0-3. Prerequisite: graduate standing.

Review of preservation and conservation as social attitudes, as public policy concerns, and as discrete areas of knowledge. Emphasis will be given to historic preservation as a specialty within the general context of the built environment.

ARCH 6403. Preservation/Conservation Methods
3-0-3.
Contemporary methods and processes of historic preservation considering technical, economic, marketing, and aesthetic problems of assessing, restoring, and adapting historical buildings for alternative occupancies.

ARCH 6406. Urban Topography
3-0-3.
Description and interpretation of the contemporary city as a complex phenomena of transformations in physical form, architectural and social history, economic and social values.

ARCH 6422. Transportation Architecture
3-0-3.
The transportation terminal as a building type and urban institution, including historical development, technological change, economic change, and architectural expression in the city.

ARCH 6441. Housing Economics
3-0-3. Prerequisite: graduate standing.
Economics of the housing delivery process in the private sector. Planning, developmental marketing, and management of housing.

ARCH 6442. Construction Cost and Valuation
3-0-3. Prerequisite: graduate standing.
Cost and valuation approaches to building construction, project development, and design from an economic valuation viewpoint. Income-producing properties are studied in depth.

ARCH 6444. Building Life-cycle Costing
3-0-3.
The concepts, techniques, and applications of life-cycle costing as a basis for evaluating architectural performance and design decisions.

ARCH 6445. Economics of Building Development
3-3-4.
An investigation of the architectural implications of the construction industry's financial procedures, practices, and requirements.

ARCH 6446. Urban Development Methods
3-0-3.
Investigations of urban development process and roles of the architect and planner in shaping the contemporary city. Methods of financial analysis, programming, and project packaging.

ARCH 6451. Professional Practice of Architecture
3-0-3. Prerequisite: graduate standing.
Principles of architectural office organization and project management, the legal framework of architectural practice and contracts, and the techniques of contract administration.

ARCH 6461. Studies in Environment and Behavior
3-0-3.

An examination of interactions between people and the designed environment, focusing on how various settings affect human safety, satisfaction, productivity, and performance.

ARCH 6462. Interdisciplinary Concepts and Values in Architecture
3-0-3.
Rationalism, empiricism, structuralism, instrumentalism, and other frameworks prevailing in the behavioral and social sciences are assessed with regard to their implications for architectural design.

ARCH 6463. Subcultural Issues in Architecture
3-0-3.
Consideration of ways cultural experience, physical ability, social class, and other issues influence the users' reactions to and use of designed environments.

ARCH 6464. Post-occupancy Evaluation
3-0-3.
Evaluations of users' response to and satisfaction with designed environments are developed using design-oriented research methods and analytic techniques.

ARCH 7000. Thesis

ARCH 7011. Architectural Design Studio
1-15-6.
Advanced problems in architectural design. Studio exercises emphasize the experimental development and application of theories and methods to complex problems.

ARCH 7021. Urban Design Studio
1-15-6.
Advanced design problems in the contemporary city formulated on theoretical positions, including considerations of utopian positions, type and typology, historical precedent, civic design, and contextualism.

ARCH 7041. Architectural Technology Studio
1-15-6.
Experimental application in architectural technology in the area of building physics, material performance, and construction methods.

ARCH 7061. Behavior in Architecture Studio
1-15-6.
Exploring new boundaries in the application of behavioral information to architectural design.

ARCH 7201. Readings in Architectural Theory
3-0-3.
Detailed critical analysis of selected works in architectural theory.

ARCH 7202. Architectural Criticism
3-0-3.
An examination of theories of criticism in architecture, historiography, film, and literature and their application to subjects in architecture and urban design.

ARCH 7221. Origin and Evolution of Cities
3-0-3.
Morphological analysis of urban physical settlement patterns. Ecological, social, economic, and cultural characteristics as determinants of urban form and structure from prehistory to present.

ARCH 7223. Language of the City
3-0-3.

Critical analysis of contemporary theories in the representation of architecture and the city in literature, graphic arts, and film.

ARCH 7224. Studies of the American Landscape
3-0-3.
A topical study of the man-made American landscape with emphasis on the theme of pastoralism in American culture.

ARCH 7441. Urban Design Workshop I
0-18-6.
Advanced problems in urban design and development in the city of Atlanta. Integration of urban design theory and methods, economic development, political negotiation, and communication.

ARCH 7442. Urban Design Workshop II
0-9-3.
A continuation of projects begun in ARCH 7441.

ARCH 7461. Behavioral Systems in Architecture
3-0-3.
An examination of models that present direct relationships between the physical organization of spaces and patterns of individual or collective behavior.

ARCH 8143-53-63-73-83-93. Special Topics
3-0-3 each.

ARCH 8151-2-4-5-6. Special Topics
1-0-1 through 6-0-6, respectively.

ARCH 8213. Special Topics - Urban Design
3-0-3.

ARCH 8223. Special Topics - History and Theory
3-0-3.

ARCH 8233. Special Topics - Architectural Technology
3-0-3.

ARCH 8243. Special Topics - Architecture and Behavior
3-0-3.

ARCH 8253. Special Topics - Architectural Research
3-0-3.

ARCH 8550-1-2-3-4-5-6. Special Problems
Credit to be arranged.

ARCH 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate teaching assistantships.

ARCH 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate research assistantships.

ARCH 8999. Preparation for Doctoral Dissertation
Credit to be arranged. Pass/fail only.

ARCH 9000. Doctoral Dissertation
Credit to be arranged. Pass/fail only.

BUILDING CONSTRUCTION

BC 1010. Building Construction Seminar
1-0-1.

An introduction to the building construction industry, the participants, and their roles in the construction process and career opportunities in building construction

BC 2010. Construction Technology I
3-6-5. Prerequisite: BC 1010.
Study and analysis of job planning, layout, building and site work methods, materials, systems, and equipment employed on light construction projects, including residential and commercial buildings.

BC 2020. Construction Technology II
3-6-5. Prerequisite: BC 2010.
Continuation of BC 2010, with emphasis on medium to large commercial, institutional, and industrial building projects.

BC 2030. Construction Cost Estimating
2-9-5. Prerequisite: BC 2020.
Introduction to cost principles and cost analysis of costruction projects, including classification of work, quantity survey techniques, construction operations cost, and the preparation of bid proposals.

BC 3310. Construction Contracting
3-0-3. Prerequisite: BC 2030.
Principles, practices, and organizational models employed in the company operations in the building construction industry and an analysis of the complexities in construction contracting.

BC 3320. Construction Law
3-0-3. Prerequisite: BC 3310.
Legal aspects of construction contracts, bonds, insurance, and bidding. Owner, architect, contractor, subcontractor relationships.

BC 3330. Real Estate and Construction Finance
3-0-3. Prerequisite: BC 3320
General introduction to the financing of construction and real estate development projects. Emphasis on financing requirements, activities, sources, and uses.

BC 4301. Construction Systems
3-0-3. Prerequisite: BC 3330 and senior standing.
Review and examination of major building systems in use today. Discussion of anticipated future requirements for systems and potential impacts on the construction process.

BC 4440. Construction Scheduling
3-6-5. Prerequisite: BC 3330.
Introduction to the principles of time analysis and scheduling practices in the project planning and control process, including network planning, CPM scheduling, resource leveling, and computer program applications.

BC 4442. Value Engineering and Construction
3-0-3. Prerequisite: BC 3330 and senior standing.
Analysis of material, equipment, facilities, procedures, and supplies to achieve the lowest possible cost consistent with performance requirements to attain optimum quality in building.

BC 4450. Building Production
3-0-3. Prerequisite: senior standing in BC or consent of the College.
Methods analysis and human factors in the construction project management and delivery process, emphasizing

organizational structures, productivity measurement, management control methods, environmental concerns, and the decision-making process.

BC 4460. Risk Management
3-0-3. Prerequisite: senior standing in BC or consent of the College.

Analysis of the construction management process dealing with preventive methods for avoiding litigation. Special attention is given to the jobs of architects, owners, and contractors. Management record keeping, personnel relationships, safety precautions, and field procedures are analyzed.

BC 4500. Terminal Project I
3-0-3. Prerequisite: senior standing in BC—degree candidates only.

Perform research and prepare a terminal project comprehensive proposal for approval by the faculty committee.

BC 4510. Terminal Project II
1-12-5. Prerequisite: BC 4500

Terminal project.

BC 4951-2-3. Special Problems in Construction
Credits to be arranged.

CITY PLANNING

CP 1100. Introduction to City Planning
3-0-3. Fall quarter.

An orientation to urban and regional planning including organization, functions, techniques, and methods of implementation.

CP 4402. Contemporary Planning and Development Issues
3-0-3.

The course examines the theoretical foundations of planning and urban development. Particular attention is paid to economic development and the institutional and social contexts in which it operates.

CP 4441. Economics and Cities
3-0-3.

The course explores the causes of growth and decline of cities and regions in the United States. Particular emphasis is given to economic factors, especially as they relate to the development process.

CP 4442. Introduction to Real Estate Investment and Development
3-0-3.

The course provides an introduction to real estate investment development, including principles of land appraisal, alternate financing vehicles and ownership forms, market analysis, and financial feasibility analysis.

CP 4801-02-03-04-05-06-07-08-09-10. Special Topics
3-0-3 each.

CP 6010. Land Use Planning
3-0-3.

Factors determining land use, location, and interrelationships of various land uses, land use studies and plan preparation, implementation of land use policies and plans.

CP 6020. Planning Legislation and Regulation
3-0-3.

Theory and use of eminent domain, taxing and police powers, enabling acts, charters, official maps, codes, restrictive covenants, controlled highway access legislation.

CP 6030. Planning Legislation and Regulation
3-0-3.

An intensive study of zoning—its history, principles, uses, and limitations through review of significant court cases and subdivision regulations.

CP 6070. Public Works Planning
3-0-3.

Planned change in context of public works planning and development, plan implementation, population analysis, public participation, conflict value assessment, and information transfer.

CP 6150. Environmental Aspects of City and Regional Planning
3-0-3.

Field analysis of noise, air, water, and spatial pollution. Students identify, evaluate, and apply city planning solutions to environmental problems.

CP 6180. Urban Spatial Management
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Examines city as three-dimensional resource: aerial, ground, subterranean land uses. City planning methods of multiple use, joint use, and adaptive use are discussed.

CP 6220. Design of Sites and Cities
1-6-3. Prerequisite: graduate standing or consent of the instructor.

Explores methods of analyzing large-scale landscapes for complex development programs in public and private sectors. Case studies are used to illustrate application of such methods.

CP 6230. Problems in Community Planning I
1-12-5. Prerequisite: graduate standing or consent of the instructor.

Preparation of a series of sectoral plans for an existing urban area. Site visits and discussion with planners, citizens, and politicians of issues and plans.

CP 6240. Problems in Community Planning II
1-12-5. Prerequisite: CP 6230 or consent of the College.

An in-depth study of a specific urban or regional planning problem prepared for a client agency or citizens' organization.

CP 6270. Economic Analysis of Urban Areas
3-0-3.

An examination of methods and techniques for analyzing the economic base of urban communities, with special emphasis on problems of handling population, employment, and income data.

CP 6300. Theory and History of Urban Planning
3-0-3 Prerequisite: graduate standing or consent of the instructor.

Introduction to the history of the planning profession; examination of theories of planning, comprehensiveness, citizen participation, professionalism, public interest, and planning roles and practices.

CP 6320. Urban Fiscal and Budget Systems
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Survey of public sector fiscal planning issues—emphasis on current and capital budgeting, debt financing, public expenditures and revenues, and analysis techniques.

CP 6330. Planning in the Intergovernmental System
3-0-3. Prerequisite: graduate standing or consent of the instructor.

The nature of the American intergovernmental system; describes how it is managed today and conveys techniques for implementing plans within that system.

CP 6375. Planning with People
3-0-3.

Problems of planning with selected subgroups in urban societies: minorities, the aged, residents of the inner city, suburbanites. Impact of environment on individuals and families.

CP 6400. Principles of Environmental and Energy Planning
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Identification and analysis of air, water, noise, and spatial pollution; energy management and its influence on urban development. Environmental controls and management programs evaluated.

CP 6410. Principles of Real Estate, Land Development, and Private Sector Planning
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Location of cities and land uses within cities; land development; market analysis and economic feasibility studies; impact of changing tax laws on private sector developers.

CP 6420. Principles of Housing, Neighborhoods, and Community Development
3-0-3. Prerequisite: senior standing.

Principles of planning for mature cities. Analyses of underlying causes of urban growth and maturity. Evaluation of national, regional, and local policies to effect change.

CP 6440. Principles of Transportation Planning
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Introduction to theory, techniques, and contemporary issues in urban transportation planning. Analysis of a practical transportation problem.

CP 6450. Introductory Quantitative Methods in Urban and Regional Planning
3-0-3. Prerequisite: graduate standing or consent of the instructor.

An introduction to various information collection, organization, analysis, and communication techniques that are essential in professional planning practice.

CP 6460. Intermediate Quantitative Methods in Urban and Regional Planning
2-6-4. Prerequisite: CP 6450 or consent of the College.

Second of a three-course sequence with an emphasis on data analysis techniques relevant to planning theory and practice.

CP 6470. Advanced Quantitative Methods in Urban and Regional Planning
2-6-4. Prerequisite: CP 6460 or consent of the College.

A continuation of CP 6460, with emphasis on computer applications.

CP 6500. History of Modern Cities
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Traces development of the American city from colonial times to late twentieth century. Documents changes in social, economic, and physical structures and institutions of urban America.

CP 6510. Growth Management
3-0-3. Prerequisite: CP 6030 or consent of the instructor.

Exposes and analyzes goals and objectives of selected local and state growth management techniques and the multitude of federal land use policies.

CP 6520. Housing Economics and Policy
3-0-3. Prerequisite: graduate standing or consent of the instructor.

Detailed examination of the operation of local housing markets and national, state, regional, and local policies intended to influence those markets.

CP 6753. Economic Aspects of Urban and Regional Planning I
3-0-3. Prerequisite: senior or graduate standing.

Introduction to cash-flow and discounting techniques. Microeconomics in project formulation and evaluation. Applications from welfare economics, project analysis, cost allocation.

CP 6754. Economic Aspects of Urban and Regional Planning II
3-0-3. Prerequisite: CP 6753.

Principles of resource allocation, benefit-cost analysis, urban and regional project formulation, justification, and application of computer simulation techniques to economic and resource allocation.

CP 7000. Master's Thesis
Credit to be arranged.

A research problem in city planning, selected by the student in consultation with the graduate staff. Requires one full quarter of work as a minimum, with technical direction available from the graduate staff.

CP 8011-21-31-41-51. Seminar—City Planning
1-0-1 each (audit only). Prerequisite: graduate standing and consent of the College.

CP 8103-4-5-7-8. Special Topics
3-0-3 each.

CP 8106. Special Topics
2-0-2.

CP 8500-1-2-3-4. Special Problems
Credit to be arranged.

CP 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.

For graduate students holding graduate teaching assistantships.

CP 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate research assistantships.

CP 8999. Preparation for Doctoral Dissertation
Credit to be arranged. Pass/fail only.

CP 9000. Doctoral Dissertation
Credit to be arranged. Pass/fail only.

INDUSTRIAL DESIGN

ID 1263. History of Design
3-0-3.
A history of design, technology, and innovation, with emphasis on their influence in historic cultures. Open to all students.

ID 2001-2-3. Industrial Design I, II, III
1-12-5 each. Corequisites: ID 2301-2-3.
Elements of industrial design, with stress on design procedures and problem solving.

ID 2301-2-3. Materials and Processes of Design I, II, III
1-3-2 each.
Use of materials and processes designers use to communicate their ideas. Graphic techniques. Use of hand and power tools with wood, metals, and plastics. Model-making techniques. Use of working drawings.

ID 3001-2-3. Industrial Design I, II, III
1-12-5 each. Prerequisite: ID 2003. Corequisites: ID 3301-2-3.
Lettering, typography, package design, and industrial design problems.

ID 3301-2-3. Materials and Processes of Design I, II, III
1-3-2 each.
Production methods and their relation to design. Includes the study of major mass production techniques involved in manufacturing products and packaging, through use of lectures, research, and field trips to production facilities.

ID 3911. Special Problems—Visual Communications—Industrial Design
Variable.

ID 4002-3. Industrial Design II, III
1-18-8 each. Prerequisite: ID 4101.
Advanced industrial design problems, accentuating individual work in special areas of concentration.

ID 4101. Industrial Design I
1-12-5. Prerequisite: ID 3003.
Product development—advanced industrial design problems, emphasizing individual work in special areas of concentration.

ID 4451. Professional Practice of Industrial Design
3-0-3.
Principles of consulting and corporate design office organization and project management relating to the practice of industrial design.

ID 4853. Special Topics—Industrial Design
3-0-3.

ID 4911. Special Problems—Visual Communications—Industrial Design
Credit to be arranged.

ID 4951-2-3. Special Problems—Industrial Design
Credit to be arranged.

College of Engineering

Dean—William M. Sangster; *Associate Dean*—W. Denney Freeston; *Director, Engineering Research and Resource Development*—Joseph C. Hogan; *Assistants to the Dean*—Carolyn C. Chesnutt, Madelyne Watson; *Director of Special Programs*—Lytia Howard.

General Information

The College of Engineering comprises eight degree-granting schools of instruction and research. The schools offer programs of study and research leading to bachelor's, master's, and doctoral degrees. Certain of the schools also offer programs in one or more subdisciplines or subspecialties. These degree offerings are summarized in an accompanying table.

The programs in engineering are designed to provide a fundamental understanding of the engineering sciences, which are based on mathematics and the natural sciences, of the basic concepts of the humanities and social sciences, and an understanding of the manner in which these elements are interwoven in engineering practice. Each curriculum provides enough flexibility through elective course opportunities to permit a certain amount of program individualism while meeting basic requirements.

Students who wish to study engineering but are undecided as to a specific engineering degree program may, for their freshman year, be classified as Undecided Engineering College (UEC) students and receive advisement from the Office of the Dean of Engineering. Course work for undecided engineering students will focus on the areas of mathematics, chemistry, physics, humanities, and the social sciences, as does the first-year course work for all engineering

degree programs. Transfer from the undecided category to schools (majors) with space limitations may not be possible for students with cumulative grade point averages below set minimums.

College of Engineering Degree Programs

	B	M	Ph.D.
Aerospace Engineering	X	X	X
Ceramic Engineering	X	X	X
Chemical Engineering	X	X	X
Civil Engineering	X	X	X
Computer Engineering	X		
Engineering Science and Mechanics	X	X	X
Environmental Engineering		X	X
Electrical Engineering	X	X	X
Health Physics	X	X	X
Health Systems		X	
Industrial and Systems Engineering	X	X	X
Mechanical Engineering	X	X	X
Metallurgy		X	X
Nuclear Engineering	X	X	X
Operations Research		X	X
Polymers		X	
Textile Engineering	X	X	X
Textile Chemistry	X	X	
Textiles	X	X	

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: EGR 1170, CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, TEX 1100.

Multidisciplinary Certificate Programs in Engineering

In addition to its degree programs, the College of Engineering provides opportunities for specialized study in engineering through its multidisciplinary certificate program offerings. Any student in good academic standing who is pursuing a degree in one of the participating schools of the College of Engineering, or a participating school in any of the other colleges, may select elective courses and the subjects of special problems to satisfy simultaneously both the requirements of his or her major degree program and those of a specialized multidisciplinary program. Upon graduation, the student receives both the degree in the major field of study and a certificate attesting to successful completion of the particular related multidisciplinary program.

The table on page 83 shows both currently available multidisciplinary program offerings and those in the planning stage, as well as the degree levels of the programs.

General Requirements of Undergraduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating undergraduate student, while individualized, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) undergraduate multidisciplinary requirements are as follows:

(1) the program must relate the student's major area to the given multidisciplinary area;

(2) courses must be taken under more than one academic unit;

(3) at least four courses and twelve credit hours (not required by name and number in the student's major) must be taken in a coherent program;

(4) at least three of those courses and nine credit hours must be at the 3000 level or higher;

(5) at least two of those courses and six credit hours must be outside the major field (cross-listed courses may be counted outside the student's major);

(6) a grade of C or better must be earned in each course counting toward a multi-disciplinary certificate.

General Requirements of Graduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating graduate student, while individualized, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) graduate multidisciplinary requirements are the same as those listed above for the undergraduate programs, with the following exceptions:

(1) at least three of the coherent multidisciplinary program courses as well as nine credit hours must be at the 6000 level or higher;

(2) a minimum grade of C must be earned in each course counting toward a multidisciplinary certificate. The overall grade point average for the course must be 3.0 or higher;

(3) students at the doctoral level must, on an individual basis, meet additional requirements specified by the student's doctoral committee, consistent with a program beyond the master's level whose objective is to develop a doctoral-level multidisciplinary program.

Interested students may obtain detailed information on the various undergraduate-level and graduate-level multidisciplinary programs from the main office of the school in which they are enrolled and through the Office of the Dean, College of Engineering.

Computer Integrated Manufacturing Systems Program

The Computer Integrated Manufacturing Systems (CIMS) multidisciplinary program awards a certificate for study at the graduate level of the integration of design, information and material processing, and management in manufacturing systems. Eight academic units participate in the program: aerospace engineering, chemical engineering, civil engineering, electrical engineering, industrial and systems engineering, information and computer science, mechanical engineering, and the College of Management. Two core courses, twenty-four hours of electives (eighteen under the thesis option), a seminar series, and a project make up the certificate requirements. Financial support is available to highly qualified students in the form of assistantships. Industry interaction and unique laboratory opportunities are available in the program.

Multidisciplinary Certificate Programs

Multidisciplinary Program Area	Related Degree Levels		
Acoustical Engineering		M	Ph.D.
Bioengineering	B	M	Ph.D.
Computer Engineering	B	M	Ph.D.
Computer Integrated Manufacturing Systems		M	Ph.D.
Energy Engineering	B	M	Ph.D.
Fusion		M	Ph.D.
Materials Engineering	B	M	Ph.D.
Mineral Engineering	B	M	Ph.D.
Plastics Engineering	B	M	Ph.D.
Pulp and Paper Engineering			
Structures Engineering	B	M	Ph.D.

School of Aerospace Engineering

Daniel Guggenheim School of Aeronautics, Established in 1930

Acting Director and Regents' Professor— Robin B. Gray; *Regents' Professors—* Edward W. Price, Warren C. Strahle, Ben T. Zinn; *Professors—*Anthony J. Calise, Robert L. Carlson, James I. Craig, Gary A. Flandro, Sathyanarayana V. Hanagud, C. Peter Hellsten, Dewey H. Hodges, Manohar P. Kamat, Howard M. McMahon, David A. Peters, G. Alvin Pierce, Lawrence W. Rehfield, Daniel P. Schrage, George J. Simitses, James C. Wu; *Professors Emeritus* —Donnell W. Dutton, John J. Harper; Wilfred F. Horton, James E. Hubbartt; *Associate Professors—*Stanley C. Bailey, Jechiel I. Jagoda, Padmanabhan K. A. Menon, Lakshmi N. Sankar, C. Virgil Smith, Jr; *Assistant Professors—*Erian A. Armanios, Narayanan M. Komerath, Richard Riff; *Senior Research Engineers—* Brady R. Daniel, Steven S. Klein, Eugene A. Powell, Robert L. Roach, Robert K. Sigman; *Research Engineers II—*Wilhelmus A. DeGroot, Uday G. Hegde, V. R. Prasad Jonnalogadda, Ralph Latham, William L. Meyer, Murugappan Meyyappa, Wei Tang, Ronald E. Walterick; *Research Engineer I—* Stephen A. Meyer; *Research Associates—* Robert S. Albright, John Caudell, Harald W. Meyer.

General Information

The School of Aerospace Engineering prepares students at the bachelor's, master's, and doctoral levels for a career in vehicle engineering, with primary emphasis on flight vehicles. The School is housed in three buildings having a floor space of 85,000 square feet, the majority of which is devoted to instructional and research laboratories.

Undergraduate Programs

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities, and social sciences. The third and fourth years emphasize aerospace disciplines and related engineering sciences. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses the theoretical, experimental, and design aspects of aerospace engineering. Courses do not have to be taken during the quarter indicated in the curriculum, but all prerequisites must be satisfied for a particular course. Advisement for registration is required.

A certain degree of specialization is available to undergraduate students through the proper choice of electives, certain substitutions for required courses, or a combination of both options, depending on the student's abilities and career objectives. Students should consult with their academic advisers for the availability of elective courses and recommended course sequences.

A grade of C or better is required by the School in each math and physics course. A 2.0 average is required to begin any of the sophomore and junior aerospace engineering courses.

Graduate Programs

The graduate programs at both the master's and doctoral levels are flexible so that

students may tailor their course and research work to individual career objectives. A minimum of fifty credit hours is required for the master's degree. The following areas of specialty are available.

Aeroelasticity
Dynamic response and loads, flutter, servoaeroelastic instabilities and control, static aeroelastic instabilities and loading, unsteady aerodynamics—V/STOL and conventional aircraft, and vibrational characteristics of vehicles.

Aerospace Systems Design
Advanced design of conventional and V/STOL aircraft. Application of optimization and knowledge-based expert systems techniques to the aerospace systems design process. Computer-aided design (CAD) and its interface with computer-aided manufacturing (CAM) in the design of aerospace systems.

Flight Mechanics and Control
Dynamic modeling, stability and control of conventional and V/STOL aircraft. Analog and digital methods for flight control system design using both classical and modern control theory. Attitude stabilization and active control of flexible space structures. Trajectory optimization and optimal control of air and space vehicles.

Fluid Mechanics
Computational fluid dynamics, helicopter aerodynamics, laminar and turbulent flows, plasma and reacting gas dynamics, statistical theory of turbulence, and V/STOL aircraft.

Propulsion
Combustion instability, external burning, propulsion system noise, solid rocket propellant research, and supersonic combustion.

Structures
Buckling and postbuckling of structures, composites, elastic and inelastic stress analysis, fracture mechanics, fatigue behavior, structural reliability and statistical methods of structural analysis, vibration and dynamic stability of structural elements, wave propa-

gation, and use of acoustic emission methods.

Urban and Societal Engineering
Air pollution, biomechanics, fire research, and noise pollution.

Facilities for each of the above academic areas are housed in the aerospace laboratories and include low-speed and high-speed wind tunnels; an anechoic chamber; combustion chamber; a combustion bomb; helicopter test stand; high- and low-temperature test machines; fatigue and creep machines; a humidity chamber; an environmental test chamber; a network of microcomputers, engineering work stations, and VAX minicomputer; analog computers and real-time simulators; data acquisition systems; time-series analyzers; a scanning electron microscope; laser-doppler velocimeter; and Raman spectroscopy equipment. These facilities are supported by a research staff and a well-equipped instrument lab and machine shop.

Multidisciplinary Programs
See table on page 83.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
EGR 1170 Visual Communication and Engineering Design	2-3-3	.....	.....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	.....
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL Humanities Elective	.....	.....	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Physics	.....	.....	4-3-5
Social Sciences/Modern Languages Electives	.....	3-0-3	3-0-3
Free Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	X-X-3	.....
TOTALS	X-X-16	X-X-19	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
AE 2101 Introduction to Aircraft Structures	.....	.....	4-0-4
AE 2603 Digital Computers	.....	.....	1-6-3
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics I	.....	3-0-3	.....
MATH 2307 Calculus IV	5-0-5	.....	.....
MATH 2308 Calculus and Linear Algebra	.....	5-0-5	.....
MATH 2309 Ordinary Differential Equations	.....	.....	5-0-5
ME 3322 Thermodynamics	.....	.....	3-0-3
PHYS 2122-3 Physics	4-3-5	4-3-5	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	.....
Free Elective	.....	.....	3-0-3
TOTALS	15-3-16	15-3-16	16-6-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
AE 3000-1-2 Fluid Mechanics I, II, III	4-3-5	4-3-5	4-3-5
AE 3103 Fundamentals of Stress Analysis	3-0-3	.....	.....
AE 3104 Energy Methods and Stability of Structures	.....	3-0-3	.....
AE 3110 Structures Lab	1-3-2	.....	.....
EE 3400 Instrumentation Lab	.....	1-3-2	.....
EE 3701 Electric Circuits	2-0-2	.....	.....
EE 3702 Elementary Electronics	.....	2-0-2	.....
ESM 4210 Mechanical Vibrations	.....	.....	3-0-3
ENGL 3020 Technical Writing	3-0-3	.....	.....
MATH 4582 Advanced Engineering Mathematics	.....	.....	3-0-3

Humanities/Social Sciences/Modern Languages Electives

	1st Q.	2nd Q.	3rd Q.
Humanities/Social Sciences/Modern Languages Electives	3-0-3	6-0-6	6-0-6
TOTALS	16-6-18	16-6-18	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
AE 4000 Fluid Mechanics IV	4-3-5	.....	.....
AE 4101 Analysis of Thin-walled Structural Elements	3-0-3	.....	.....
AE 4102 Selected Topics in the Analysis of Aircraft Structures	.....	.....	3-0-3
AE 4110 Structures Lab	1-3-2	.....	.....
AE 4200 Vibration and Flutter	.....	.....	3-0-3
AE 4251 Jet Propulsion	.....	4-0-4	.....
AE 4350-1 Aerospace Engineering Design Project I, II	.....	2-6-4	2-6-4
AE 4410 Vehicle Performance	3-0-3	.....	.....
AE 4500 Stability and Control	.....	5-0-5	.....
Free Electives	3-0-3	3-0-3	6-0-6
TOTALS	14-6-16	14-6-16	14-6-16

REQUIREMENTS
A grade of C or better is required in each math and physics course. A 2.0 average is required to begin any of the sophomore or junior aerospace engineering courses.

SUBSTITUTIONS
EE 1010 or ICS 1700 cannot be substituted for AE 2603, Digital Computers, nor used as free electives.

ELECTIVES
Humanities/Social Sciences/Modern Languages Electives
Eighteen credit hours in humanities and eighteen credit hours in social sciences are required for graduation. To satisfy these requirements, humanities and social sciences courses must be selected from the College of Engineering listings in "Information for Undergraduate Students" (see pp. 41-42).

Courses taken in humanities and social sciences must be scheduled as letter grade courses. ENGL 1001-2 plus three credit hours of English humanities electives are required as a minimum.

All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled. No more than nine credit hours of advanced ROTC may be applied toward the requirements for a degree.

Courses of Instruction

AE 2101. Introduction to Aircraft Structures
4-0-4. Prerequisites: ESM 2201, 2.0 overall average. Pre- or corequisite: MATH 2308.
Introduction to elements of structural mechanics that are used in the design of aircraft and missile structures.
Text: Crandall, et al., *An Introduction to the Mechanics of Solids.*

AE 2603. Computer Applications in Aerospace Engineering
1-6-3. Prerequisite: MATH 1309.
Description of the components of a modern digital computing system. Elementary FORTRAN programming. Introduction to aerospace engineering applications.
Text: at the level of Merchant, *FORTRAN 77: Language and Style.*

AE 3000. Fluid Mechanics I
4-3-5. Prerequisites: ME 3322, 2.0 overall average, and a 2.0 average in math and in physics. Pre- or corequisite: MATH 2309.
The atmosphere, fluid properties, classification of flows and one-dimensional flows, including isentropic flows, normal shocks, and duct flows with friction and heating.

AE 3001. Fluid Mechanics II
4-3-5. Prerequisites: ME 3322, 2.0 overall average, and a 2.0 average in math and in physics. Pre- or corequisite: MATH 2309.
The physical equations for continuum flows and application to laminar and turbulent boundary layers for incompressible and compressible flow.
Text: at the level of Kuethe and Chow, *Foundations of Aerodynamics.*

AE 3002. Fluid Mechanics III
4-3-5. Prerequisites: 2.0 overall average and a 2.0 average in math and in physics. Pre- or corequisite: MATH 2309.

Two-dimensional incompressible flow theory, super-positioning and conformal transformations, with applications to flow around bodies and to airfoil theory.
Text: at the level of Kuethe and Chow, *Foundations of Aerodynamics.*

AE 3103. Fundamentals of Stress Analysis
3-0-3. Prerequisite: AE 2101. Pre- or corequisite: MATH 2309.
Stresses in unsymmetrical bending. Deflections due to bending. Two-dimensional problems in elasticity.
Text: at the level of Megson, *Aircraft Structures for Engineering Students.*

AE 3104. Energy Methods and Stability in Structures
3-0-3. Prerequisite: AE 2101. Pre- or corequisite: MATH 2309.
Introduction to stability analysis with applications to columns and plates. Principle of virtual work and energy principles.
Text: at the level of Megson, *Aircraft Structures for Engineering Students.*

AE 3110. Structures Lab
1-3-2. Pre- or corequisite: AE 2101.
Introduction to theory of measurements and to methods for determining mechanical properties.
Texts: Crandall, et al., *An Introduction to Mechanics Solids;* Holman, *Experimental Methods for Engineers.*

AE 4000. Fluid Mechanics IV
4-3-5. Prerequisites: AE 3000, 3001, 3002.
Finite wing theory, two-dimensional subsonic and supersonic compressible flows, supersonic flow around bodies of revolution and an introduction to transonics and hypersonics.
Text: at the level of Kuethe and Chow, *Foundations of Aerodynamics.*

AE 4101. Analysis of Thin-walled Structural Elements
3-0-3. Prerequisite: AE 3103.
Torsion of noncircular solid cross sections. Bending of thin-walled open and closed section beams.
Text: at the level of Megson, *Aircraft Structures for Engineering Students.*

AE 4102. Selected Topics in the Analysis of Aircraft Structures
3-0-3. Prerequisites: AE 3103 and 3104.
Selected topics from among the following: shear webs, shear lag, matrix methods, composite materials, fracture and fatigue, applications of virtual work principle, connections.

AE 4110. Structures Lab
1-3-2. Prerequisite: AE 3110. Pre- or corequisites: AE 3103, 3104.
Introduction to methods of experimental stress analysis on a variety of structural elements.
Text: Holman, *Experimental Methods for Engineers.*

AE 4200. Vibration and Flutter
3-0-3. Prerequisites: AE 3002, ESM 4210. Pre- or corequisite: MATH 4582.
Structural dynamics of one-dimensional systems. Analysis of static aeroelastic phenomena and flutter. Equations of motion for complete aeroelastic system and solution techniques.

AE 4251. Jet Propulsion
4-0-4. Prerequisite: AE 4000.
The theory and principles of jet propulsion. The mechanics and thermodynamics of combustion. Component and cycle analysis. Engine performance characteristics.
Text: at the level of Hill and Peterson, *Mechanics and Thermodynamics of Propulsion.*

AE 4350-1. Aerospace Engineering Design Project I, II
2-6-4 each. Prerequisite: AE 4000. Pre- or corequisite: AE 4410, 4500.
Preliminary design or case study of an aerospace system, such as a complete flight vehicle, a propulsion system, a structural system, or a control system.

AE 4400. Introduction to Propeller and Rotor Theory
3-0-3. Pre- or corequisite: AE 4000 or consent of the School.
A study of the theory and equations used in the design of propellers and helicopter rotors.
Text: at the level of Gessow and Myers, *Aerodynamics of the Helicopter.*

AE 4410. Vehicle Performance
3-0-3. Prerequisites: AE 3001, 3002. Pre- or corequisite: AE 4000.
A study of basic aerodynamic-vehicle performance, including drag estimation, horsepower-thrust required and available, basic point and path performance, special performance items, maneuvers and resultant air loads.

AE 4500. Stability and Control
5-0-5. Prerequisites: AE 4000, ESM 4210.
Principles of static lateral and longitudinal stability and studies of the equations and methods used in analysis. Applications to airplane and missile systems.
Text: at the level of Etkin, *Dynamics of Flight,* and Franklin et al, *Feedback Control of Dynamic Systems.*

AE 4550. Instrumentation for Experimental Research I
2-3-3. Prerequisite: consent of the School.
Laboratory treatment of major and ancillary instrumentation used in solid and fluid mechanics research, voltage, current, resistance measurement, transducers, amplifiers, oscilloscopes, recording equipment.

AE 4551. Instrumentation for Experimental Research II
2-3-3. Prerequisite: AE 4550 or consent of the School.
Advanced treatment of laboratory instrumentation for research, analysis, and application of operational amplifiers, filters and signal conditioners, elementary digital circuits, computer systems for data acquisition.

AE 4600. Computational Fluid Dynamics
3-0-3. Prerequisites: AE 2603 and 4000 or equivalent.
Panel methods for subsonic flow. Finite difference approximations for Laplace's equation and relaxation methods. Integral boundary layer techniques and viscous/inviscid interaction. Subsonic airfoil design.

AE 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.
Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as ESM 4760, ME 4760.

AE 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: AE 4760 or equivalent.
Continuation of AE 4760, emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as ESM 4761, ME 4761.

AE 4770. Structural Integrity and Durability
3-0-3. Prerequisite: ESM 3301 or AE 2101.
Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep, and relaxation. Introduction to fatigue and fracture mechanics. Crack-growth calculations and wearout models.

AE 4803-13-23-33-43-53. Special Topics
3-0-3 each. Prerequisite: consent of the School.
Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4804-14-24-34-44-54. Special Topics
4-0-4 each. Prerequisite: consent of the School.
Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4805-15-25-35-45-55. Special Topics
5-0-5 each. Prerequisite: consent of the School.
Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4900-1-2. Special Problems in Aerospace Engineering
Credit to be arranged. Prerequisites: third quarter junior or senior standing and approval of the director.
Research on a problem selected in consultation with a faculty member. A brief description, endorsed by the adviser, must be approved by the School director.

AE 6001. Foundations of Fluid Mechanics
4-0-4. Prerequisite: consent of the School.
Development of the conservation equations of a multicomponent, reacting fluid from both the continuum and molecular viewpoints. Stress tensor, heat transfer vector, and diffusion velocity.
Text: Vincenti and Kruger, *Physical Gas Dynamics.*

AE 6010. Viscous Flow I
3-0-3. Prerequisite: AE 6001 or consent of the School.
Exact solutions of Navier-Stokes equations, Stokes flow, boundary layer equations, similarity solutions and integral methods for incompressible flow, compressible laminar boundary layer, viscous hypersonic flow.

AE 6011. Viscous Flow II
3-0-3. Prerequisite: AE 6010 or consent of the School.
Transition from laminar to turbulent flow, equations of motion for turbulent flows, incompressible boundary layers, compressibility and heat transfer, semiempirical methods, wakes and jets.

AE 6020. Elements of Compressible Flow
3-0-3. Prerequisite: consent of the School.

Defining equations for inviscid compressible flows, method of characteristics for unsteady one-dimensional and steady two-dimensional and axially symmetric flows, nozzle design, conical flow.

AE 6021. Advanced Compressible Flow Theory I
3-0-3. Prerequisite: AE 6020 or consent of the School.
The linearized potential equation, thin airfoil theory, similarity rules, linear theory for axially symmetric and three-dimensional flows.

AE 6022. Advanced Compressible Flow Theory II
3-0-3. Prerequisite: AE 6021.
Mixed subsonic-supersonic flows, transonic similarity rule, two-dimensional and axially symmetric bodies in transonic flow, selected topics.

AE 6023. Hypersonic Flow Theory
3-0-3. Prerequisite: AE 6021 or consent of the School.
Hypersonic similarity rule, hypersonic small disturbance theory, Newtonian flow theory and other approximate methods, boundary layer interaction, the blunt body problem.

AE 6030. Advanced Potential Flow I
3-0-3. Prerequisite: AE 3002.
Development of the nonlinear and linearized unsteady potential flow equations. Solutions to incompressible flow problems of airfoils and wings undergoing steady, oscillatory, and arbitrary motions.

AE 6031. Advanced Potential Flow II
3-0-3. Prerequisite: AE 6030.
Formulation of aerodynamic influence coefficients, solutions to subsonic, supersonic, and hypersonic flow problems of wings and bodies experiencing oscillatory and arbitrary motions.

AE 6050. High-temperature Gas Dynamics I
3-0-3. Prerequisite: AE 6260 or consent of the School.
Real gas effects. Equilibrium properties and rate processes of high-temperature gases. Equilibrium and frozen flows, normal and oblique shocks, nozzle flows, Prandtl-Meyer flows.

AE 6051. High-temperature Gas Dynamics II
3-0-3. Prerequisite: AE 6050.
Acoustic equations and rate equations. Vibrational and chemical nonequilibrium flows, normal and oblique shock structures, theory of nonequilibrium characteristics, non-equilibrium acoustic waves, flow over corners.

AE 6100. Advanced Structural Analysis I
3-0-3. Prerequisite: AE 3104 or consent of the School.
Stability of mechanical models, elastic bars, and frames by kinetic and energy approaches, approximate methods for critical loads, dynamic stability, and inelastic effects.

AE 6101. Advanced Structural Analysis II
3-0-3. Prerequisite: AE 6100 or consent of the School.
Buckling of plates, torsional instability of thin open section columns, lateral buckling of beams, beams on elastic foundations, further discussion of dynamic stability.

AE 6102. Advanced Structural Analysis III
3-0-3. Prerequisite: AE 6100, ESM 6372, or consent of the School.
Stability of plates, cylindrical shells, edge effects, complete spheres and shallow spherical caps, recent developments.

AE 6103. Advanced Structural Analysis IV
3-0-3. Prerequisite: AE 3104 or consent of the School.
Principle of virtual work. Concepts of potential energy and complementary energy, weighted residuals, applications in approximate solutions. Discussion of Hookean material, including thermal strains.

AE 6104. Advanced Structural Analysis V
3-0-3. Prerequisite: AE 6103 or consent of the School.
Introduction to finite element analysis, with emphasis on the displacement analysis of structures. Applications, static equilibrium, vibration and stability, nonlinear formulation, solution techniques.

AE 6105. Aerospace Structures Laboratory
1-6-3. Prerequisite: AE 6104 or consent of the School.
Development of practical methods for experimental mechanics, design and execution of experiments, measurement of displacement, strain, force, acceleration, temperature, design of transducers, and instrument systems.

AE 6120. Thermal Effects in Structures I
3-0-3. Prerequisite: MATH 4582.
Analysis of heat transfer in structural elements, development, and use of approximate numerical and analytical solution procedures.

AE 6121. Thermal Effects in Structures II
3-0-3. Prerequisite: ESM 6321 or consent of the School.
Analysis of thermally induced stresses in beams, plates, and shells, thermally induced instability in columns and plates, reduction in torsional rigidity.

AE 6122. Thermal Effects in Structures III
3-0-3. Prerequisite: ESM 6321 or consent of the School.
Phenomenological and mechanistic interpretations of mechanical behavior of solids. Formulation and solution of problems involving elastic, plastic, linear, and nonlinear viscoelastic and viscoplastic behavior.

AE 6130. Structural Dynamics I
3-0-3. Prerequisites: AE 3103, ESM 4210.
Single and multiple degree-of-freedom systems, damping effects, Duhamel superposition integral. Normal modes and equations of motion, Lagrange's equations, methods of obtaining normal modes.

AE 6131. Structural Dynamics II
3-0-3. Prerequisite: AE 6130.
Vibrations of continuous elastic systems. Stodola and Rayleigh-Ritz methods. Timoshenko beam, longitudinal vibrations. Elastic and plastic waves, analysis of complex structures by modal coupling.

AE 6200. Advanced Aeroelasticity I
3-0-3. Prerequisite: AE 6130.
Static aeroelastic analyses of flight vehicles, lifting surface and panel flutter analyses with applications. Dynamic response and load studies of flight vehicles using modal techniques.

AE 6201. Advanced Aeroelasticity II
3-0-3. Prerequisite: AE 6200.
Formulation of aeroelastic analyses associated with discrete and random dynamic loads, aerodynamic and structural instabilities of fixed- and rotating-wing flight vehicles.

AE 6202. Experimental Aeroelasticity
3-0-3. Prerequisite: AE 6200.
Analog computing techniques with applications, flexibility influence coefficient measurements. Vibration testing for modal identification, wind tunnel and inflight flutter tests including model scaling and construction.

AE 6203. Special Topics in Aeroelasticity I
3-0-3. Prerequisite: AE 6200.
Current topics in aeroelasticity, unsteady aerodynamics, and structural dynamics are studied. The student presents both an oral and written report on two specialized current problems.

AE 6204. Special Topics in Aeroelasticity II
3-0-3. Prerequisite: AE 6200.
Continuation of AE 6203. Advanced problems in aeroelasticity, unsteady aerodynamics, or structural dynamics.

AE 6250. Rocket Propulsion I
3-0-3. Prerequisite: AE 4251.
Flight mechanics, performance of the ideal rocket engine. Properties and performance characteristics of chemical propellants, nozzle designs, and losses.

AE 6260. Thermodynamics of Gases
4-0-4. Prerequisite: consent of the School.
Thermodynamics of reacting gases. Introductory quantum theory, statistical thermodynamics, and chemical kinetics.

AE 6261. Combustion I
3-0-3. Prerequisite: AE 6260 or consent of the School.
Introductory chemical kinetics, explosions, Schvab-Zeldovich formulation. Rankine-Hugoniot relations, detonations, and deflagrations.

AE 6262. Combustion II
3-0-3. Prerequisite: AE 6261.
Laminar diffusion flames and droplet burning. Laminar flame propagation in premixed gases, turbulent flames, ignition quenching, and flammability limits. Chemical reactions in boundary layers.

AE 6400. Aerodynamics of the Helicopter I
3-0-3. Prerequisite: AE 4400.
Forward flight performance, derivation and study of the induced velocity relations and the flow field associated with helicopter rotors.

AE 6401. Aerodynamics of the Helicopter II
3-0-3. Prerequisite: AE 6400.
Vortex-wake theories for rotors with a finite number of blades, introduction to helicopter stability and control.

AE 6460. Aerodynamic Noise
3-0-3. Prerequisite: AE 6761.
Jet, boundary layer, combustion, propeller, and fan noise. Sonic boom, noise propagation from engines, and attenuation techniques.

AE 6500. Advanced Stability and Control
3-0-3. Prerequisite: AE 4500.
A study of feedback controls as applied to aircraft; root locus techniques and use of airframe transfer functions are emphasized. Survey of the load alleviation problem.

AE 6760. Engineering Acoustics I
3-0-3. Prerequisite: consent of the School.

Introductory analytical methods, stochastic processes, the wave equation in a compressible fluid, and problems in the radiation of sound. Also taught as ESM 6760 and ME 6760.

AE 6761. Engineering Acoustics II
3-0-3. Prerequisite: AE 6760.
Sound reflection and refraction, scattering and diffraction, sound radiation, and duct acoustics. Also taught as ESM 6761 and ME 6761.

AE 6762. Engineering Acoustics III
3-0-3. Prerequisite: AE 6761.
Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics. Also taught as ESM 6762 and ME 6762.

AE 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisites: AE 4760 or equivalent and 6760.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction, and damping methods. Also taught as ESM 6763 and ME 6763.

AE 6800. Numerical Fluid Dynamics I
3-0-3. Prerequisite: AE 6010 or consent of the School.
Finite-difference and finite-element methods for the numerical solution of fluid dynamic equations. Current methods for the numerical solution of potential flow and boundary layer problems.

AE 6801. Numerical Fluid Dynamics II
3-0-3. Prerequisite: AE 6800.
Numerical methods of solution of boundary layer equation and Navier-Stokes equations for time-dependent and steady flows. Accuracy, stability, and computational efficiency.

AE 7000. Master's Thesis

AE 7600. Perturbation Methods in Engineering Analysis
3-0-3. Prerequisite: consent of the School.
Regular and singular perturbation theory, WKBJ method, and the method of weighted residuals. Problems drawn from fluid mechanics and structures.

AE 7999. Preparation for Doctoral Qualifying Exams
Noncredit. Prerequisite: consent of the director.

AE 8000. Seminar
1-0-1.

AE 8103-13-23-33-43-53. Special Topics
3-0-3 each. Prerequisite: consent of the School.
Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 8104-14-24-34-44-54. Special Topics
4-0-4 each. Prerequisite: consent of the School.
Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 8105-15-25-35-45-55. Special Topics
5-0-5 each. Prerequisite: consent of the School.
Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 8106-16-26-36-46-56. Special Topics
6-0-6 each. Prerequisite: consent of the School.
Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 8500-1-2. Special Problems in Aerospace Engineering
Credit to be arranged. Prerequisite: consent of the School.

AE 8503-4-5. Special Problems in Aerospace Engineering
Credit to be arranged.

AE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

AE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

AE 8999. Preparation for Doctoral Dissertation
Noncredit. Prerequisite: consent of director.

AE 9000. Doctoral Thesis

School of Chemical Engineering

Established in 1901

Director and Professor—Ronald W. Rousseau; *Associate Director and Professor*—Jude T. Sommerfeld; *Professors*—Agaram S. Abhiraman, Eric J. Clayfield, Charles W. Gorton, Michael J. Matteson, John D. Muzzy, Gary W. Poehlein, Robert J. Samuels, A. H. Peter Skelland, Amyn S. Teja, Jack Winnick; *Professors Emeritus*—H. Clay Lewis, Clyde Orr, Jr., Henderson C. Ward, Waldemar T. Zeigler; *Associate Professors*—Pradeep K. Agrawal, Yaman Arkun, William R. Ernst, Larry J. Forney, Jeffrey S. Hsieh, Ronnie S. Roberts, D. William Tedder, Mark G. White, Ajit P. Yoganathan; *Assistant Professor*—F. Joseph Schork; *Adjunct Professors*—Charles Aloisio, Samuel Brockway, George A. Fowles, Tudor Thomas.

General Information

Chemical engineers perform essential functions in industries that convert raw materials into useful finished products by means of chemical and physical processes. Almost every major manufacturing industry employs chemical engineers in research, develop-

ment, design, production, sales, consulting and management positions. Industries that employ substantial numbers of chemical engineers include petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemical, mineral, pharmaceutical, textile, electronic, and dye. Energy problems and environmental and pollution control activities also require an increasing number of chemical engineers.

The School of Chemical Engineering offers programs leading to the Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, and Doctor of Philosophy. Interdisciplinary programs and undesignated degrees are also available.

The following curriculum leads to the Bachelor of Chemical Engineering and seeks to train students not only for positions immediately upon graduation but also for additional study leading to the master's and doctoral degrees.

It is a regulation of the School of Chemical Engineering that any student who accumulates a total of three or more grades of *F, D,* or *W* in required chemical engineering courses will not be permitted to enroll in any more chemical engineering courses and or will not be certified for graduation by the School. Exceptions to this regulation will be permitted only after the affected student submits a specific written petition for exemption from this regulation and approval of said petition by the faculty of the School of Chemical Engineering. Also, a grade of *D* is not an acceptable passing grade for each of the five required mathematics courses (MATH 1307, 1308, 1309, 2307, and 2308).

A six-week summer study program in the Department of Chemical Engineering of the University College London in London, England, was initiated in the 1975 summer quarter. Selected juniors who participate in this program are allowed twelve credit hours of free or technical electives, some of which may be substituted for selected chemical engineering laboratory and social sciences courses.

Students whose previous academic backgrounds differ substantially from that of Georgia Tech are strongly advised to con-

sider lightened academic loads during their first several quarters at Georgia Tech. Such students may also wish to audit one or two of the first sophomore courses in chemical engineering (CHE 2207 and 2208) before electing these required courses for credit.

The School of Chemical Engineering requires that all of its students have a working knowledge of the FORTRAN programming language before scheduling any sophomore-level courses.

Graduate Programs

The School of Chemical Engineering offers a graduate program of advanced study and research in chemical engineering. Chemical engineering graduate work can lead to the Master of Science and the Doctor of Philosophy degrees, both involving a combination of advanced-level courses and independent research or design work.

Master's degree candidates must complete a research or design thesis. Course selection for both the master's and doctoral degrees is quite flexible, with individual plans of study developed for each student.

Research opportunities exist in a broad range of areas of importance to chemical engineers and society, including air pollution control, biochemical engineering, polymer science, process design and simulation, catalysis, chemical reaction engineering, development of alternate energy sources, biomedical engineering, pulp and paper engineering, transport phenomena, fine particle technology, minerals processing, thermodynamics, electrochemical engineering, and process control.

In response to the need for scientists and engineers with advanced training in polymers, the Schools of Chemical Engineering and Textile Engineering at Georgia Tech both offer M.S. and Ph.D. programs in polymers. The core requirements for the polymer program are the same in each School. This core is designed to provide a balanced treatment of the chemistry, physics, and engineering of polymeric materials. At the same time the wide range of elective courses and research projects available permits students to develop their in-depth knowledge in a particular area of polymer science or engineering.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 1101 Introduction to Chemical Engineering	1-0-1	.....	.....
CHEM 1111-2 General Chemistry	4-3-5	4-3-5	.....
CHEM 2113 Chemical Principles	.....	.....	3-3-4
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
English Elective ENGL 2101, 2201, 2301, or 2401	.....	.....	3-0-3
MATH 1307-8-9 Calculus	5-0-5	5-0-5	5-0-5
Freshman Engineering Elective	.....	X-X-3	.....
Physical Education PE 1040 or 1061	.....	X-X-3	.....
Electives	3-0-3	.....	6-0-6
TOTALS	16-3-17	X-X-19	17-3-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 2207-8 Chemical Process Principles	3-0-3	3-0-3	.....
CHE 2210 Chemical Engineering Analysis	.....	.....	3-0-3
CHE 2310 Fluid Mechanics	.....	.....	3-0-3
MATH 2307-8 Calculus	5-0-5	5-0-5	.....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381 Organic Chemistry Laboratory	.....	0-6-2	.....
Elective	.....	.....	3-0-3
TOTALS	15-3-16	15-9-18	16-3-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 3311 Heat Transfer	3-0-3	.....	.....

Course			
CHE 3302-3 Transport Phenomena Laboratory I, II	0-3-1	0-3-1	.....
CHE 3312 Mass Transfer	.....	3-0-3	.....
CHE 3313 Stagewise Operations	.....	.....	3-0-3
CHE 3320-1 Chemical Engineering Thermodynamics	3-0-3	3-0-3	.....
CHEM 3411-2-3 Physical Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3481 Physical Chemistry Laboratory	.....	.....	0-6-2
ESM 2201 Statics	3-0-3	.....	.....
EE 3701 Electrical Circuits	.....	2-0-2	.....
EE 3702, 3703, or 3400	.....	.....	X-X-2
MET 3301 Engineering Materials	.....	4-3-5	.....
Electives	6-0-6	.....	6-0-6
TOTALS	18-3-19	15-6-17	X-X-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 4415 Reactor Design	3-0-3	.....	.....
CHE 3309-10 Unit Operations Laboratory 1, II	0-3-1	0-3-1	.....
ICS 2250 Technical Information Resources	1-0-1	.....	.....
CHE 4431 Chemical Engineering Economics	3-0-3	.....	.....
CHE Design Elective CHE 4433 or 4449	.....	2-3-3	.....
CHE 4436 Plant Design	.....	.....	1-9-4
CHE 4417-18 Process Control	3-0-3	2-3-3	.....
Electives	9-0-9	9-0-9	12-0-12
TOTALS	16-3-17	13-9-16	13-9-16

SUBSTITUTIONS

CHEM 1111-2, advanced-level chemistry, is required for all chemical engineering majors. Students transferring into chemical engineering from other curricula not requiring the advanced-level chemistry will be allowed to substitute CHEM 1101-2 for CHEM 1111-2, respectively, if taken prior to transferring.

ELECTIVES

The chemical engineering curriculum contains fifty-one hours of electives to be chosen from four groups in the normal distribution indicated to satisfy the requirements of the School of Chemical Engineering—humanities (nine), social sciences (eighteen), technical (twelve), and free (twelve). These electives may be taken at any time and in an order during the student's course of study. Up to twelve hours of these electives may be taken on a pass/fail basis. Transfer students are restricted to fewer pass/fail hours.

English Electives

ENGL 1001-2 and ENGL 2XXX, with the latter course to be selected from ENGL 2101, 2201, 2301, or 2401, are required for all chemical engineering majors and satisfy nine hours of the total humanities requirement of eighteen hours.

Students transferring into chemical engineering from other curricula not requiring these specific English courses or students granted advanced placement for these courses will be allowed to substitute any nine hours of humanities for these English requirements. International students may substitute FL 1031-2-3 for these English requirements and six hours of electives; only FL 1032 and 1033 may be used to help satisfy the humanities requirement.

Freshman Engineering Elective

Any of the following courses are acceptable for credit as freshman engineering electives: EGR 1170, CERE 1010, CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

Humanities and Social Sciences Electives

See "Information for Undergraduate Students," Humanities and Social Sciences Requirements (p. 41-42), for the College of Engineering requirement and a listing of acceptable electives in these two groups. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

A modern language is recommended for students considering graduate work.

Technical Electives

The technical elective requirement of the School of Chemical Engineering may be satisfied by any twelve hours of advanced engineering courses provided the course is not repetitious of a previous course. A suggested list of technical electives is available from the chemical engineering office, and all questions concerning this requirement should be directed to the chemical engineering office. Technical electives should be taken in the junior and senior years.

Free Electives

Twelve hours of free electives are provided so that a student will be able to pursue specific interests. See the ROTC and Physical Education Credit sections for the maximum hours in these areas that may be applied toward degree requirements. If six credit hours of basic ROTC are elected, they should be scheduled beginning the first quarter the student is enrolled. No course covering the same material as other courses in a student's plan of study can be used as a free elective.

Multidisciplinary Programs

See table on page 83.

Courses of Instruction

CHE 1101. Introduction to Chemical Engineering
1-0-1.
An orientation to chemical engineering. Nature of chemical engineering, the types of opportunities available, and the requirements for graduation and a successful career.

CHE 1110. Elements of Chemical Engineering Design
2-3-3. Prerequisite: freshmen only or consent of the School.
An introduction to chemical engineering design in which simplified problems of current interest are used as a basis for a design project. Basics of FORTRAN programming.
Text: at the level of Rudd, Watson, and Siirola, *Process Synthesis*, and Ageloff and Mojena, *Applied FORTRAN*, 77.

CHE 2207. Chemical Process Principles I
3-0-3. Prerequisite: MATH 1309 and FORTRAN knowledge. Corequisite: CHEM 2113.
The material balance is developed. Gas behavior, systems of units, and material and thermodynamic properties are discussed. Emphasis is on the application of material balances to steady-state physical and chemical processes.
Text: at the level of Felder and Rousseau, *Elementary Principles of Chemical Processes*, 2nd Edition.

CHE 2208. Chemical Process Principles II
3-0-3. Prerequisite: CHE 2207.
A continuation of CHE 2207. The energy balance is developed. Thermophysical and thermochemical concepts are discussed. Emphasis is on the application of combined material and energy balances to steady- and unsteady-state physical and chemical processes.
Text: at the level of Felder and Rousseau, *Elementary Principles of Chemical Processes*, 2nd Edition.

CHE 2210. Chemical Engineering Analysis
3-0-3. Corequisite: CHE 2208.
Quantitative analysis of chemical engineering processes. Numerical methods are introduced and applied to the solution of chemical engineering problems. Emphasis is placed on solving problems by digital computer.
Text: at the level of Hornbeck, *Numerical Methods*.

CHE 2310. Fluid Mechanics
3-0-3. Corequisite: CHE 2208.
Fundamental principles and applications of momentum transfer. The analysis of chemical engineering processes and operations involving fluid flow.
Text: at the level of Geankopolis, *Transport Processes and Unit Operations*, 2nd Edition.

CHE 3302. Transport Phenomena Laboratory I
0-3-1. Prerequisite: CHE 2310.
Laboratory experiments in momentum and energy transfer.

CHE 3303. Transport Phenomena Laboratory II
0-3-1. Prerequisite: CHE 3311.
Laboratory experiments in heat and mass transfer.

CHE 3309. Unit Operations Laboratory I
0-3-1. Prerequisite: CHE 3313.
Laboratory experiments in stagewise operations.

CHE 3310. Unit Operations Laboratory II
0-3-1. Prerequisite: CHE 3312.
Laboratory experiments in diffusional processes.

CHE 3311. Heat Transfer
3-0-3. Corequisites: CHE 2210, 2310, 3320.
Fundamental principles and applications of energy transfer. The analysis of chemical engineering processes and operations involving heat transfer.
Text: at the level of Incropera and DeWitt, *Fundamentals of Heat Transfer*.

CHE 3312. Mass Transfer
3-0-3. Corequisites: CHE 2310, 3320.
Fundamental principles and applications of mass transfer. The analysis of chemical engineering processes and operations involving mass transfer.
Text: at the level of Treybal, *Mass Transfer Operations*, 3rd Edition.

CHE 3313. Stagewise Operations
3-0-3. Prerequisite: CHE 2208. Corequisite: CHE 3321.

Topics in stagewise operations.

Text: at the level of Henley and Seader, *Equilibrium Stage Separation Operations in Chemical Engineering*.

CHE 3320. Chemical Engineering Thermodynamics I
3-0-3. Prerequisite: CHE 2208.

Principles of thermodynamics with industrial applications. Applications of first and second laws, engines, air conditioning, turbines, equations of state, fluid properties, corresponding states.

Text: at the level of Reynolds and Perkins, *Engineering Thermodynamics*, 2nd Edition.

CHE 3321. Chemical Engineering Thermodynamics II
3-0-3. Prerequisite: CHE 3320.

Principles of thermodynamics with industrial applications. Phase equilibria, fugacity, activity, mixtures, nonideal solutions, gas solubility, reaction equilibria.

Text: at the level of Van Ness and Abbott, *Classical Thermodynamics of Nonelectrolyte Solutions*.

CHE 3750. Introduction to Biofluid Dynamics
3-0-3. Prerequisite: MATH 2309, PHYS 2123, or consent of the instructor.

Study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research applications.

Also taught as AE 3750 and ESM 3750.

CHE 4111. Mineral Engineering: Fossil Fuels
3-0-3.

An introductory course in fossil fuels. Gives majors in engineering a background in fuels and raw materials.

CHE 4414. Air Pollution Control
3-0-3.

Application of mass transfer principles to the design of pollution control systems utilizing adsorption, absorption, filtration, and precipitation. Other topics are process optimization, fuel pretreatment.

Text: at the level of Work and Warner, *Air Pollution— Its Origin and Control*.

CHE 4415. Reactor Design
3-0-3. Prerequisites: CHE 3321, CHEM 3313, 3413.

Kinetics and mechanisms of industrial chemical reactions. Effects of temperature, pressure, and concentrations on the rates of chemical reactions. Design of batch, backmix, tubular, and semibatch reactors.

Text: at the level of Hill, *An Introduction to Chemical Engineering Kinetics and Reactor Design*.

CHE 4417. Process Control I
3-0-3. Prerequisite: EE 3701. Corequisite: CHE 4415.

Dynamics of chemical processes and theory of control techniques. Mathematics using primarily Laplace transforms is applied with instrumentation and process constraints to system design.

Text: at the level of Stephanopoulos, *Chemical Process Control*.

CHE 4418. Process Control II
2-3-3. Prerequisite: CHE 4417.

Theory of digital control. Applications to the process industries. Laboratory experiments in system dynamics and analog and digital control.

Text: at the level of Stephanopoulos, *Chemical Process Control*.

CHE 4431. Chemical Engineering Economics
3-0-3. Prerequisite: CHE 3312. Corequisite: CHE 3313.

A study of techniques required in project analysis in areas of systems cost analysis and the use of the economic balance for design and optimization.

Text: at the level of Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*.

CHE 4433. Chemical Process Synthesis, Design, and Optimization
2-3-3. Prerequisites: CHE 2208, 3313, 4431.

Principles of chemical flowsheet creation and integration with recognized design constraints. Applications of heuristic rules, dynamic programming, and multivariate state optimization to minimize processing costs.

Text: at the level of Rudd and Watson, *Strategy of Process Engineering*.

CHE 4436. Design of Chemical Plants
1-9-4. Prerequisites: ICS 2250 and all other required CHE courses.

Complete design of a chemical process and plant, incorporating concepts of unit operations, reactor design, economics, and process control.

CHE 4449. Computer-aided Process Design
2-3-3. Prerequisites: CHE 2210, 3321, or consent of the School.

A study of the synthesis and operation of large-scale computer systems for steady-state simulation of chemical processes as a design tool.

Text: at the level of Seader, *FLOWTRAN Simulation— An Introduction* and the *PROCESS Input Manual*.

CHE 4453. Polymerization Process Analysis
3-0-3. Prerequisites: MET 3301, CHE 4415, or consent of the School.

Polymerization processes are analyzed with regard to reaction mechanisms, kinetics, and reactor design. Methods of controlling polymer structure during polymerization are emphasized.

CHE 4455. Plastics Industry Manufacturing Policy
3-0-3. Prerequisite: consent of the School.

Case studies of practical problems contributed by industry concerning plastics manufacturing, marketing, and management. Decision-making processes in the plastics industry are emphasized.

Text: at the level of Skinner and Rogers, *Manufacturing Policy in the Plastics Industry*.

CHE 4750. Polymer Science and Engineering I
3-0-3. Prerequisites: CHEM 1102, PHYS 2123.

An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems, and methods of polymer identification are presented. Also taught as TEX 4750.

Text: at the level of Rodriguez, *Principles of Polymer Systems*.

CHE 4751. Polymer Science and Engineering II
3-0-3. Prerequisites: CHEM 1102, PHYS 2123.

An introduction to the physical states and transitions, fabrication processes, and mechanical properties of polymers. Also taught as TEX 4751.

Text: at the level of Rodriguez, *Principles of Polymer Systems*.

CHE 4753. Survey of Pulp and Paper Technology
3-0-3.

A survey is made of the mechanical systems used in paper manufacture. The chemistry of pulp preparation and nonfibrous additives is outlined. Also taught as TEX 4753.

CHE 4760. Polymer Science and Engineering Laboratory
1-6-3. Corequisite: CHE 4751.

Experiments in polymerization, processing, and property evaluation of polymers. Also taught as TEX 4760.

CHE 4771. Pulp and Paper Processes I
3-0-3. Prerequisite: consent of the School.

A survey of the processes in a kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, wood chemistry, and morphology. The chemical and mechanical characteristics of kraft pulping and chemical recovery processes. Also taught as ME 4771.

CHE 4772. Pulp and Paper Processes II
3-0-3. Prerequisite: consent of the School.

The major pulping processes other than kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleaching process. Also taught as ME 4772.

CHE 4773. Paper Formation and Properties
3-0-3. Prerequisite: consent of the School.

The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as ME 4773 and TEX 4773.

Text: at the level of Casey, *Pulp and Paper: Chemistry and Chemical Technology*, Vol. 2.

CHE 4801-2-3-4-5-6. Special Topics
1 through 6 credit hours, respectively. Prerequisite: consent of the School.

Topics relevant to chemical engineering not currently covered in the undergraduate curriculum are presented as demand or interest warrants.

CHE 4901-2-3. Special Problems
Credit to be arranged. Prerequisite: CHE 3311.

The student is given an opportunity to develop initiative and to apply fundamental principles by doing semioriginal laboratory or theoretical investigation of a chemical engineering problem.

CHE 6001. Biochemical Engineering I
3-0-3. Prerequisite: consent of the instructor.

Engineering aspects of enzyme systems. Transport phenomena in biological systems and elementary biological reactor design.

CHE 6002. Biochemical Engineering II
3-0-3. Prerequisite: consent of the School.

Advanced biological reactor design. Analysis of complex biological systems.

CHE 6417. Advanced Process Control I
3-0-3. Prerequisite: CHE 4418.

Fundamentals of multivariable control systems as applied to chemical processes. State-space and frequency domain representations, principles of feedback, analysis and synthesis of robust control systems. Application of alternative methods using computer-aided design.

CHE 6418. Advanced Process Control II
3-0-3. Prerequisite: CHE 4418.

Techniques of system identification, state estimation and optimal, adaptive, and pole placement control of chemical process systems. Both continuous and discrete systems are discussed.

CHE 6449. Computer-aided Batch Process Design
2-3-3. Prerequisite: CHE 4449

A study of discrete-event and continuous systems for the simulation of batch chemical processes as a design tool. Generalized (GPSS, SLAM) and dedicated (BOSS) systems are investigated.

Text: at the level of Schriber, *Simulation Using GPSS*.

CHE 6601. Chemical Engineering Thermodynamics I
3-0-3. Prerequisite: CHE 3321 or consent of the School.

The laws of thermodynamics with application to pure substances and mixtures. Calculation of thermodynamic properties. Elements of molecular thermodynamics and potential functions. The corresponding states principle and its applications. Equations of state. Phase equilibrium calculations at high pressures.

Text: at the level of Prausnitz, *Molecular Thermodynamics of Fluid Phase Equilibria*.

CHE 6602. Chemical Engineering Thermodynamics II
3-0-3. Prerequisite: CHE 6601 or consent of the School.

Thermodynamics of solutions. Ideal and nonideal nonelectrolyte solutions. Phase equilibria involving gas, liquid, and solid phases. Molecular properties of liquids and liquid mixtures. Engineering applications.

Text: at the level of Prausnitz, *Molecular Thermodynamics of Fluid Phase Equilibria*.

CHE 6607. Thermochemical Conversion
3-0-3. Prerequisite: CHE 4434 or consent of the School.

Thermochemical conversion to fuels or chemical feedstocks with emphasis on feed materials of solid wastes and biomass.

CHE 6610. Aerosol Technology
3-0-3. Prerequisite: consent of the School.

Presents basic concepts describing the behavior of dispersed particles. Includes generation, sampling and size analysis, diffusion, coagulation, settling, kinetics and dynamics, electrostatic and optical properties.

Text: at the level of Mercer, *Aerosol Technology*.

CHE 6611. Industrial Emission Control
3-0-3. Prerequisite: consent of the School.

Air quality criteria, ambient and emission standards, and industrial sources are analyzed. Recovery and utilization of waste gaseous and particulate matter are presented.

Text: at the level of Crawford, *Air Pollution Control Theory*.

CHE 6612. Atmospheric Reactions
3-0-3. Prerequisite: consent of the School.

The principles of atmospheric chemical and photochemical reactions, including primary and derived air

pollutants, sources and sinks of carbon, nitrogen, sulfur, and oxygen compounds.

Text: at the level of Seinfeld, *Air Pollution, Physical and Chemical Fundamentals*.

CHE 6613. Technology of Fine Particles
3-0-3. Prerequisite: CHE 3311 or consent of the School.

An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, absorptivity, catalytic behavior, and process engineering operations.

Text: at the level of Allen, *Particle Size Measurement*.

CHE 6615. Transport Phenomena I
3-0-3. Prerequisite: CHE 3311 or consent of the School.

Advanced theory and applications of momentum transport.

Text: at the level of Bird, Stewart, and Lightfoot, *Transport Phenomena*.

CHE 6616. Transport Phenomena II
3-0-3. Prerequisite: CHE 6615 or consent of the School.

Advanced theory and applications of energy transport.

Text: at the level of Bird, Stewart, and Lightfoot, *Transport Phenomena*.

CHE 6617. Transport Phenomena III
3-0-3. Prerequisite: CHE 6616 or consent of the School.

Advanced theory and applications of mass transport.

Text: at the level of Bird, Stewart, and Lightfoot, *Transport Phenomena*.

CHE 6619. Chemical Engineering Calculations I
3-0-3. Prerequisites: CHE 3313, MATH 2308.

A study of the application of classical mathematical methods (including Laplace transforms and Bessel functions) to the solution of typical chemical engineering problems.

Text: at the level of Jenson and Jeffries, *Mathematical Methods in Chemical Engineering*, 2nd Edition.

CHE 6620. Chemical Engineering Calculations II
3-0-3. Prerequisite: CHE 6619 or consent of the School.

A study of the application of modern mathematical techniques (including numerical methods and optimization procedures) to the solution of typical chemical engineering problems.

Text: at the level of Jenson and Jeffries, *Mathematical Methods in Chemical Engineering*, 2nd Edition.

CHE 6622. Advanced Reactor Design
3-0-3. Prerequisite: CHE 4415.

A study of chemical kinetics and mechanisms in complex homogeneous and heterogeneous reaction systems. Design of chemical reactors for such systems.

Text: at the level of Smith, *Chemical Engineering Kinetics*.

CHE 6635. Advanced Unit Operations III
3-0-3. Prerequisite: CHE 3313.

Vapor-liquid equilibrium and separation by distillation of binary and multicomponent mixtures. Factors influencing design and performance of fractionating equipment. Application of azeotropic and extractive distillation.

Text: at the level of Robinson and Gilliland, *Elements of Fractional Distillation*.

CHE 6750. Polymer Structure and Physical Properties I
3-0-3. Prerequisite: consent of the School.

Morphology and structure, linear and nonlinear viscoelasticity, anistropic mechanical properties, and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as TEX 6750.

Text: at the level of Ward, *Mechanical Properties of Solid Polymers*.

CHE 6751. Polymer Structure and Physical Properties II
3-0-3. Prerequisite: consent of the School.

Structure-property relationships of elastomers, reinforced plastics, fibers, foams, and natural polymers, with emphasis on proteins and the composite nature of all polymers and polymer products. Also taught as TEX 6751.

Text: at the level of Ward, *Mechanical Properties of Solid Polymers*.

CHE 6753. Surface Science and Technology Laboratory
3-18-9. Prerequisite: consent of the School.

A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials. Also taught as CHEM 6753 and PHYS 6753.

CHE 6754. Electrochemistry
3-0-3. Prerequisite: consent of the School.

A study of electrochemical instrumentation; the thermodynamics, structure, absorption of the electrical double layer, and the kinetics of simple and complex electrode processes. Also taught as CHEM 6754.

Text: at the level of Bockris and Reddy, *Modern Electrochemistry*, Vol. 2.

CHE 6775. Advanced Engineering Programming Methods
3-3-4. Prerequisite: FORTRAN programming knowledge.

Advanced engineering programming concepts and their implementation on large-scale digital computers, dynamic data, dynamic programs, engineering data management, primary memory management, engineering problem-oriented language development, and ICES. Also taught as CE 6775 and NE 6775.

CHE 6787. Heterogeneous Catalysis
3-0-3. Prerequisite: CHE 6622 or consent of the instructor.

Physics and chemistry of surfaces, thermodynamics, kinetics and mechanism of chemisorption and surface reactions; industrial catalysts. Also taught as MET 6787.

Text: at the level of Satterfield, *Heterogeneous Catalysis in Practice*.

CHE 7000. Master's Thesis
Credit to be arranged.

CHE 7750. Surface and Solution Properties of Polymers
3-0-3. Prerequisite: consent of the School.

Study of plasticized polymers, solutions, and colloids; sorption, polymer characterization; interfacial phenomena, and coagulation using thermodynamics, statistical mechanics, information, and fluctuation theories and relaxation methods. Also taught as TEX 7750.

CHE 7751. Energetics
3-0-3. Prerequisite: consent of the School.

Energetics applied to polymers and fibers using Newtonian mechanics, thermodynamics, statistical thermodynamics, and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials. Also taught as TEX 7751.

CHE 7752. Kinetics
3-0-3. Prerequisite: consent of the School.

Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes, and irreversible thermodynamics. Also taught as TEX 7752.

CHE 7753. Polymer Flow
3-0-3. Prerequisite: CHE 6750 or TEXT 6750 or consent of the School.

The fluid mechanics, heat transfer, and mixing of non-Newtonian fluids. Experimental methods for characterizing fluids and the extrusion of polymer melts are emphasized. Also taught as TEX 7753.

CHE 7999. Preparation for Doctoral Qualifying Examinations
Noncredit. Prerequisite: consent of the director.

Students who are preparing for their qualifying examinations will be expected to register for this course. Occasionally this may be the only course for which a student is registered.

CHE 8011-12-13. Seminar
1-0-1. Audit only. Advanced.

Presentation of advanced research and design topics in chemical engineering.

CHE 8069. Heterogeneous Catalysis Seminar
1-0-1. Audit only. Prerequisite: consent of the instructor.

Presentation of advanced research and development topics relating to heterogeneous catalysis.

CHE 8101-2-3-4-5-6. Special Topics in Chemical Engineering
1 through 6 credit hours, respectively. Prerequisite: consent of the School.

Topics relevant to chemical engineering not currently covered in the graduate curriculum are presented as demand or interest warrants.

CHE 8500. Special Problems in Chemical Engineering
Credit to be arranged.

Lectures, laboratory, and library work on special problems of current interest in chemical engineering.

CHE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

CHE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate research assistantships.

CHE 9000. Doctoral Thesis
Credit to be arranged.

School of Civil Engineering
Established in 1896

Director and Professor—J. Edmund Fitzgerald; *Associate Director*—Paul H. Sanders; *Regents' Professors*—Satya N. Atluri, Andrew W. Marris, George F. Sowers; *Professors*—Appiah Amirtharajah, Richard D. Barksdale, Austin B. Caseman (Undergraduate Coordinator, CE), Edward S. K. Chian, Donald O. Covault, Leroy Z. Emkin, Wilton W. King (Graduate Coordinator, ESM), James S. Lai, William J. Lnenicka, Charles S. Martin, David J. McGill (Undergraduate Coordinator, ESM), Peter S. Parsonson, Frederick G. Pohland, Quentin L. Robnett, William M. Sangster, Thomas E. Stelson, Charles E. S. Ueng, James T. S. Wang, Gerald A. Wempner, Earl M. Wheby, Paul H. Wright (Graduate Coordinator, CE), Wan-Lee Yin; *Associate Professors*—Mustafa M. Aral, Donald G. Berghaus, Michael C. Bernard, Hyland Y. L. Chen, Barry J. Goodno, Achintya Haldar, Lawrence F. Kahn, Arthur J. Koblasz, Leland S. Riggs, Philip J. W. Roberts, F. Michael Saunders, Robert W. Shreeves, Terry W. Sturm, Kenneth M. Will; *Assistant Professors*—Robert C. Bachus, Aristidis Georgakakos, Roozbeh Kangari, Kenneth W. Reed, Walter E. Rodriguez, Shahrokh Rouhani, Neil D. Williams, Benjamin Wilner, Abdul H. Zureick; *Adjunct Professor*—Patrick M. Quinlan; *Senior Research Scientist*—Wendall H. Cross; *Senior Research Engineer*—Manuel J. Moskaluk; *Research Scientists II*—Joseph P. Gould, David B. Green, Peter A. Jensen, Stacy V. Stringer; *Research Engineers II*—Michael H. Swanger, Chien-Tung Yang; *Research Scientists I*—Suk Young Cho, Gregory Hopkins, David W. Parker; *Research Engineers I*—Robert S. Abernathy, Sandeep Chawla, Catherine Lee, Michael T. Lee, Sing-Gee Lin, Hamid Zand.

General Information
The School of Civil Engineering offers courses in civil engineering, engineering science and mechanics, and engineering

graphics and programs leading to the degrees Bachelor of Civil Engineering, Bachelor of Engineering Science and Mechanics, Master of Science in Civil Engineering, Master of Science in Engineering Science and Mechanics, Master of Science in Environmental Engineering, Master of Science (undesignated), and Doctor of Philosophy. Also offered is a two-year program leading to the degrees Master of Science in Civil Engineering or Master of Science (undesignated), major in transportation engineering, and Master of City Planning.

Multidisciplinary Programs
See table on page 83.

Program in Engineering Graphics

The School of Civil Engineering offers EGR 1170, Introduction to Visual Communication and Engineering Design. Many engineering curricula require this course; other engineering and nonengineering curricula accept engineering graphics as an elective.

The objective of the course is to teach the student the principles of computer graphic expression. Thus, the student should schedule this course during the freshman year, so that principles learned therein may be used in later engineering courses.

Bachelor of Civil Engineering

The four-year curriculum leading to the degree Bachelor of Civil Engineering enables the graduate to enter professional practice as an engineer or to continue his or her studies in programs leading to advanced degrees in the following broad fields of specialization: computational mechanics, construction management, environmental engineering, fluid mechanics, hydraulics, hydrology, materials, soil mechanics, structures, transportation, and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations, and maintenance. Since the inauguration of its accrediting program in 1936-1938, the Accreditation Board for Engineering and

Technology has continuously accredited the curriculum leading to the Bachelor of Civil Engineering degree. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are listed here. Although students do not have to take the courses during the quarter indicated, they must satisfy all prerequisites for a particular course.

In addition to campuswide academic requirements for graduation with a bachelor degree, the following are also required for the B.C.E. degree.

(a) A grade of C or better must have been earned in MATH 1307-8-9, PHYS 2121, BIOL 1720, CHEM 1101 and ESM 2201.

(b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.

(c) No more than eleven hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Students who complete both the bachelor's and master's degrees in the School of Civil Engineering may use up to nine credit hours of graduate level course work (as approved by the School of Civil Engineering) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within two years after the award date of the bachelor's degree.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101 Inorganic Chemistry	4-3-5	.....	.....
BIOL 1720 Biological Principles	.....	4-3-5	.....
PHYS 2121 Physics	.....	.....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communications and Engineering Design	2-3-3	.....	.....
CE 1503 Introduction to Civil Engineering	.....	2-3-3	.....
CE 3513 Digital Computers	.....	.....	3-0-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Free Electives	1-0-1	1-0-1	.....
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TOTALS	X-X-17	X-X-17	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Physics	4-3-5	.....	.....
PHYS 2123 Physics or			
CHEM 1102 Inorganic Chemistry	.....	4-3-5	.....
CE 2264 Surveying	.....	.....	3-3-4
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3709 Mathematics for Systems Engineering	.....	.....	3-0-3
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics	.....	3-0-3	.....
ESM 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Electives	1-0-1	1-0-1	1-0-1
TOTALS	16-3-17	16-3-17	15-3-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ECON 2000 Economics	3-0-3	.....	.....
CE 3224 Structural Analysis	3-3-4	.....	.....
CE 3534 Stochastic Methods	3-3-4	.....	.....
GEOS 2100 Physical Geology	3-0-3	.....	.....
GEOS 2102 Physical Geology Laboratory	0-3-1	.....	.....
ME 3720 Thermodynamics or			
CHEM 2113 Chemical Principles	X-X-4	.....	.....
CE 4108-18 Environmental Engineering I, II	.....	3-0-3	3-0-3
CE 3309 Materials of Construction	.....	3-3-4	.....
CE 3053-4 Fluid Mechanics I, II	.....	3-0-3	3-3-4
ENGL 3020 Technical Writing	.....	3-0-3	.....
Free Elective	.....	3-0-3	.....
CE 4204 Metal Structural Components	.....	.....	3-3-4
CE 4154 Behavior of Soil and Rock	.....	.....	3-3-4
EE 3701 Elements of Electrical Circuits	.....	.....	2-0-2
EE 3400 Electrical Instrumentation Laboratory	.....	.....	1-3-2
TOTALS	X-X-19	15-3-16	15-12-19

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
CE 4214 Concrete Structural Components	3-3-4	.....	.....
CE 4163 Soil and Rock Engineering	2-3-3	.....	.....
CE 3061 Fluid Mechanics Laboratory	0-3-1	.....	.....
CE Electives	3-0-3	3-0-3	3-0-3
CE 4353 Hydrology	3-0-3	.....	.....

Humanities/Social Sciences/Modern Languages Electives	3-0-3	6-0-6	6-0-6
CE 4304 Transportation Engineering I	.....	3-3-4	.....
ISYE 4725 Engineering Economy	.....	3-0-3	.....
CE 4003 Construction	.....	.....	2-3-3
Free Elective	.....	.....	3-0-3
TOTALS	14-9-17	15-3-16	14-3-15

PREREQUISITES
CHEM 1102 is prerequisite for CHEM 2113, recommended for specialization in environmental engineering. PHYS 2123 is corequisite for ME 3720.

SUBSTITUTIONS
Any of the following courses are acceptable substitutes for CE 1503: CERE 1101, CHE 1110, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

ELECTIVES
Humanities/Social Sciences/Modern Languages Electives
See "Information for Undergraduate Students" section of this catalog for Humanities and Social Sciences requirements (pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement. All Humanities/Social Sciences/Modern Languages Electives must be taken on a letter-grade basis.

Free Electives
These free elective courses may be taken at any time during a student's course of study. Physical education courses may not be used to satisfy this requirement, except for PE 3100, which may be used as a free elective. Six hours of free electives at the 3000 level or higher, excluding physical education, must be taken if advanced ROTC is not taken.

CE Electives
Nine hours of electives are required from 4000-level CE courses, not otherwise required in the B.C.E. curriculum, or graduate-level CE courses as approved by adviser and director (a minimum average of 2.7 is required for an undergraduate to take a graduate course). At least six of the nine hours must be in CE 4013, 4053, 4128, 4223, 4233, 4313, or graduate-level CE design courses.

Master of Science
Three master's degress are available within the civil engineering program: Master of Science in Civil Engineering, Master of Science in Environmental Engineering, and the undesignated Master of Science. Common requirements for these degrees, in addition to those specified in the section "Information for Graduate Students," are listed below.
1. A minimum of fifty hours of course work, none of which was used to satisfy requirements for a previous degree, is required with the approval of the student's adviser and the director (see exceptions below).
2. Up to fifteen of the fifty hours can be in 3000- or 4000-level courses. Courses required for the B.C.E. degree cannot be used to satisfy this requirement; other 3000- or 4000-level courses may be used with the approval of the adviser and director (see exceptions below).
3. Up to six of the fifty hours may be taken on a pass/fail basis with the approval of the adviser and director.
4. Each M.S. student must either (a) write an M.S. thesis and schedule at least seventeen hours of CE 7000 or (b) write an M.S. special research problem and schedule between six and twelve hours of CE 8756. No more than seventeen hours of CE 7000, nor more than twelve hours of CE 8756, may count as part of the fifty hours required for the M.S. degree.
5. Students electing to write an M.S. thesis must take at least eighteen hours of course work in their major field. Students electing to write an M.S. special research problem must take at least twenty-seven hours of

course work (including CE 8756) in their major field.
Only those students who have previously earned the B.C.E. or its equivalent may receive the Master of Science in Civil Engineering. The School awards the Master of Science in Environmental Engineering only to those students who have previously earned the B.C.E. or who have earned an accredited bachelor's degree in engineering and have taken those undergraduate courses (for no credit toward the M.S.) required by their adviser and the director. Students who do not meet the above requirements but satisfy all prerequisites for the courses in their M.S. program receive the undesignated Master of Science degree.
A wide range of M.S. programs is available in fields such as computational mechanics, construction management, environmental engineering, fluid mechanics, hydraulics, hydrology, soil mechanics, materials, structures, transportation, and water resources planning and management. The School encourages latitude in the selection of courses in an M.S. program provided the resulting program leads to a definable goal.
The degree Master of Science in Environmental Engineering is accredited by the Accreditation Board for Engineering and Technology. The undesignated Master of Science is not an engineering degree; holders of this degree may not be licensed as professional engineers unless they have an ABET accredited bachelor's degree in engineering.
Students who complete both the bachelor's and master's degrees in civil engineering may use up to nine credit hours of graduate-level course work (as approved by the CE School) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within two years after the award date of the bachelor's degree.
Graduates of technology programs are not directly admissible to graduate study in the School of Civil Engineering.
Noncitizens seeking admission to graduate study are required to submit a minimum

TOEFL score of 550 or to have been in residence at a United States university for a full academic year.

Doctor of Philosophy
The Ph.D. is the highest degree awarded and as such requires the highest level of proficiency and achievement, both in knowledge and in the performance of research presented in a written dissertation. While there are no specific course requirements, most doctoral students spend approximately two years in course work beyond the bachelor's degree while conducting their research activities, plus at least another year on full-time research. There is no longer a Ph.D. language requirement.

Program in Engineering Science and Mechanics
Established in 1959, the engineering science and mechanics program consists of an undergraduate curriculum leading to the degree Bachelor of Engineering Science and Mechanics and graduate programs leading to the degrees Master of Science, Master of Science in Engineering Science and Mechanics, and Doctor of Philosophy.
The undergraduate curriculum prepares students for careers in engineering and related fields through emphasis on the fundamental principles and techniques in mathematics and the engineering sciences—solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer, and thermodynamics. The curriculum, totaling 206 credit hours, provides for seventy-four hours of electives, including sixteen hours of free electives, twenty-four hours of technical electives, twenty-four hours of humanities/social sciences/modern languages electives, and three hours of physical education electives. Students must pass the six required mathematics courses through the sophomore year with a grade of C or better. The engineering science and mechanics curriculum is considered particularly well suited to the better-than-average student who has not yet formulated specific goals within the general framework of engineering and the physical sciences.

Elective options provide in-depth study in interdisciplinary, technically related areas as well as preparation for professional schools of business, law, and medicine. Thus, the engineering science and mechanics graduate has a wide choice of specialized areas that can provide a foundation for starting his or her career or for entering postgraduate study.

Graduate study and research in engineering science and mechanics include work in modern continuum mechanics, stress analysis, stability, structures, dynamics, vibrations, space mechanics, fracture mechanics, finite element methods and other computational techniques, fluid mechanics, biomechanics, acoustics, wave propagation, applied stochastic processes, optimization techniques, materials science, and experimental stress analysis. The ESM graduate student will also find a great number of related courses in the other schools of the Institute. The program encourages flexibility and interdisciplinary interests in the planning of individual programs of study.

The faculty members of the engineering science and mechanics program hold degrees in most of the recognized branches of engineering as well as in mathematics and physics. Housed in the Mason Building, ESM has excellent classroom, office, and shop facilities and modern, newly equipped laboratories. Various grants, assistantships, and fellowships are available to students of outstanding merit.

Multidisciplinary Programs
See table on page 83.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Freshman Engineering Elective	X-X-3	.....	.....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	.....
EGR 1170 Visual Communication and Engineering Design	.....	2-3-3	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Physics	.....	.....	4-3-5

Course	1st Q.	2nd Q.	3rd Q.
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
English Elective ENGL 2101, 2201, 2301 or 2401	.....	.....	3-0-3
Free Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TOTALS	X-X-16	X-X-16	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 2101-2 Engineering Design I, II	0-3-1	0-6-2	.....
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201-2 Dynamics I, II	.....	3-0-3	3-0-3
EE 3200 Elements of Electrical Engineering	.....	.....	3-0-3
MATH 2307 Calculus IV	5-0-5	.....	.....
MATH 2308 Calculus and Linear Algebra	.....	5-0-5	.....
MATH 3308 Differential Equations	.....	.....	5-0-5
PHYS 2122-3 Physics	4-3-5	4-3-5	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Elective	.....	.....	3-0-3
TOTALS	15-6-17	15-9-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3111 Experimental Methods in Engineering Science	.....	.....	2-3-3
ESM 3301 Mechanics of Deformable Bodies	5-0-5	.....	.....
ESM 3302 Mechanics of Materials	.....	3-0-3	.....
ESM 3501 Fluid Mechanics	.....	.....	5-0-5
ESM 4210 Mechanical Vibrations	.....	.....	3-0-3

Course	1st Q.	2nd Q.	3rd Q.
EE 3250 Elements of Electrical Engineering	3-0-3	.....	.....
EE 3400 Instrumentation Laboratory	.....	1-3-2	.....
ENGL 3020 Technical Writing	3-0-3	.....	.....
ME 3322 Thermodynamics	3-0-3	.....	.....
ME 3323 Thermodynamics	.....	3-0-3	.....
ME 3345 Conduction and Radiation Heat Transfer	.....	.....	3-0-3
MATH 3110, 4215, 4320, or 4582	.....	3-0-3	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	.....
Free Electives	.....	3-0-3	3-0-3
TOTALS	17-0-17	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3451 Computer Applications in Engineering Science and Mechanics	3-0-3	.....	.....
ESM 4122-3 Projects in Engineering Science	0-3-1	0-6-2	.....
ECON 2000 Survey of Principles of Economics	3-0-3	.....	.....
MET 3301 Engineering Materials	4-3-5	.....	.....
ME 4445 Automatic Control	.....	.....	3-0-3
MATH 3110, 4215, 4320, 4581, or 4582	.....	3-0-3	.....
PHYS 3143 or 3751	.....	3-0-3	.....
Technical Electives	3-0-3	6-0-6	6-0-6
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Elective	.....	.....	4-0-4
TOTALS	16-6-18	15-6-17	16-0-16

ELECTIVES
Freshman Engineering Elective
Any of the following courses are acceptable for credit as freshman engineering electives: EGR 1170, CERE 1101, CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

Free Electives
These free elective hours may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, they should be scheduled beginning in the first quarter the student is enrolled. A maximum of nine hours of free electives in the junior and senior years may be in advanced ROTC.

Humanities/Social Sciences/Modern Languages Electives
See "Information for Undergraduate Students" section for Humanities and Social Sciences requirements (pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Technical Electives
At least six hours of electives must be in the area of design, synthesis, or systems. If PHYS 3138 or 3143 is chosen as the physics elective, the extra two credits will be used as technical electives.

Courses of Instruction
Note: Some ESM courses are offered on an alternate-year basis. The designation "even years" in a course description refers to even academic years, e.g., 84-85, 86-87. "Odd years" refers to odd academic years, e.g., 85-86, 87-88.

CIVIL ENGINEERING

CE 1503. Introduction to Civil Engineering
2-3-3.
What engineering is, what civil engineering is, and what civil engineers do. The civil engineering approach to the solution of man's problems.

CE 2264. Plane Surveying
3-3-4. Prerequisite: EGR 1170.
Use of modern instruments and office procedures to obtain and analyze field data for use in engineering planning, design, and construction. Introduction to photogrammetry.

CE 3053. Fluid Mechanics I
3-0-3. Prerequisite: ESM 3201.

Elementary mechanics of fluids with emphasis on analysis, fluid kinematics, equations of motion, momentum and energy principles, surface and form resistance.

CE 3054. Fluid Mechanics II
3-3-4. Prerequisite: CE 3053.
Elementary mechanics of fluids with emphasis on engineering applications. Enclosed conduit flow, open-channel flow, hydraulic machinery, fluid measurements, dynamic similitude.

CE 3061. Fluid Mechanics Laboratory
0-3-1. Prerequisite: CE 3054.
Experiment, demonstration, and analysis of basic fluid phenomena and exercises in laboratory techniques.

CE 3224. Structural Analysis I
3-3-4. Prerequisite: ESM 3301.
Determination of internal forces and deflections in statically determinate trusses, beams, and frames. Introduction to analysis of statically indeterminate structures and to formulation of influence lines.

CE 3254. Advanced Surveying I
3-3-4. Prerequisite: CE 2254.
Field astronomy. Precise taping, leveling, triangulation, sub-tense bar, adjustments of level nets and triangulation figures, special problems in land division, introduction to photogrammetry.

CE 3309. Materials of Construction
3-3-4. Prerequisites: ESM 3301, GEOL 2100, 2102.
Basic principles of the properties of materials. Physical, chemical, and mechanical properties of metals, concrete, timber, masonry, and asphalt. The laboratory period is for tests, demonstrations, and writing reports.

CE 3513. CE Applications of Digital Computers
3-0-3. Prerequisite: MATH 1308.
The application of digital computers to the solution of civil engineering problems using FORTRAN. This course is prerequisite to all civil engineering courses shown in civil engineering curriculum beginning first quarter, junior year.

CE 3534. Stochastic Methods and Applications in Civil Engineering
3-3-4. Prerequisite: MATH 2308.
Identification and modeling of nondeterministic problems in civil engineering and treatment thereof relative to engineering design and decision making. Probability and simulation models in the various areas of civil engineering.

CE 4003. Construction
2-3-3. Prerequisite: ISYE 4725.
The construction industry, contracts, and forms of construction company organization. Financing, equipment, manpower, and materials. Time and cost control methods are introduced.

CE 4013. Design of Construction Operations
3-0-3. Prerequisite: junior standing.
Modeling and analysis of construction operations at the job site level. Productivity calculations and allocation of construction resources.

CE 4053. Applied Hydraulics
3-0-3. Prerequisites: CE 3054, 4353.

Analysis and design of hydraulic works and structures. Typical exercises: stability of dams, spillway design, stilling basins, culverts, pipe systems, sediment transport, erosion and erosion control.

CE 4063. Introduction to Environmental Fluid Mechanics
3-0-3. Prerequisite: CE 3054.
Introduction to fluid mechanical aspects of the water environment as applied to lakes, rivers, estuaries, and coastal zones. Mechanisms of transport processes and flushing. Practical engineering applications.

CE 4108. Environmental Engineering I
3-0-3. Prerequisites: MATH 2308, CHEM 1101.
Introduction to physical, chemical, and biological properties of the aquatic environment with reference to environmental quality. Quality of water for domestic use. Basic principles of aquatic microbiology and chemistry.

CE 4118. Environmental Engineering II
3-0-3. Prerequisite: CE 4108. Corequisite: CE 3054.
Introduction to waste and water treatment processes. Physical, chemical, and biological principles of biological treatment for BOD removal. Coagulation, sedimentation, filtration, nutrient removal, and other treatment processes. Engineering of treatment systems.

CE 4128. Environmental Engineering III
2-3-3. Prerequisite: CE 4118.
The layout, hydraulic process, and operational design of water and waste water systems. Supervised design problems and inspection trips.

CE 4133. Engineering Aspects of Environmental Health
3-0-3. Prerequisite: CE 4118.
Sanitary engineering in public health administration and control of environmental health problems.

CE 4138. Environmental Monitoring and Impact Assessment
3-0-3.
An introduction to techniques of monitoring and assessing the impacts of engineering systems on environmental quality.

CE 4142. Environmental Microbiology Laboratory
1-3-2. Corequisite: CE 4148.
Basic laboratory exercises and discussions for the understanding of fundamental and applied microbiological principles in environmental engineering.

CE 4143. Man in His Environment
3-0-3.
Open to students from all fields. On population, resources, wastes, and health as related to development of science and technology.

CE 4148. Application of Microbiology in Environmental Engineering
3-0-3.
Introduction to fundamental and applied microbiological principles in environmental engineering, with emphasis on microbial growth and metabolism in biological processes.

CE 4154. Physical Behavior of Soil and Rock
3-3-4. Prerequisites: CE 3309, GEOS 2100, 2102.

An introduction to the engineering properties of soil and rock. The origin, composition, and structure of soils. The effect of water and control.

CE 4163. Soil and Rock Engineering
2-3-3. Prerequisite: CE 4154.
Mechanics of soil and rock masses as applied to civil engineering design and construction, footing and pile foundations, retaining walls, bulkheads, fills, embankments, control of landslides.

CE 4204. Metal Structural Components
3-3-4. Prerequisites: CE 3309, 3224.
Principles of behavior of tension and compression members, beams, and connections, with application to the design of elementary structures.

CE 4213. Structural Analysis II
2-3-3. Prerequisites: CE 3513, 3224.
Flexibility and stiffness matrix methods of static structural analysis. Computer programming.

CE 4214. Concrete Structural Components
3-3-4. Prerequisites: CE 3309, 3224.
Principles of behavior of reinforced concrete beams, columns, and slabs, with application to the design of elementary structures.

CE 4223. Structural Design
2-3-3. Prerequisites: CE 4204, 4214, 4154.
Design of structures in metal and concrete with emphasis on buildings and bridges.

CE 4233. Design in Timber and Prestressed Concrete
2-3-3. Corequisite: CE 4214.
Principles of behavior of timber and of prestressed concrete structural members, application to the design of elementary structures.

CE 4283. Advanced Route Surveying
2-3-3. Prerequisite: CE 2264.
Horizontal and vertical curves in transportation systems, application of transition curves, earthwork computations, problems involving fixed points and relocations.

CE 4304. Transportation Engineering I
3-3-4. Prerequisite: CE 3309.
Planning, design, and construction of streets and highways. Computer-oriented laboratory problem acquaints student with modern highway design techniques and criteria.

CE 4313. Transportation Engineeering II
3-0-3. Prerequisite: senior standing.
History and economics of transportation systems, traffic and planning problems and techniques, planning and design of air, rail, highway, and water transportation facilities as a system.

CE 4353. Hydrology
3-0-3. Prerequisite: CE 3054.
Occurrence and movement of water of the earth, hydrologic measurements, elementary meteorology, precipitation, evapotranspiration and runoff, ground water, frequency analysis.

CE 4363. Applied Hydrology
3-0-3. Prerequisites: CE 3054, 4353. Winter quarter.

Applications of hydrology in the design of hydraulic structures for water supply, irrigation, power, drainage, and flood control facilities.

CE 4373. Water Resources Development
2-2-3. Prerequisite: CE 4353. Spring quarter.
Comprehensive planning for water resources management, identification of needs, problems and issues, alternative creative solutions, economic and financial evaluation, institutional settings, and public participation.

CE 4383. Groundwater Hydrology
3-0-3. Prerequisites: CE 4353, GEOL 2100. Spring quarter.
Occurrence, distribution, and movement of water below the surface of the earth, groundwater resources, and dependable supply rates from wells, artificial recharge, and waste disposal.

CE 4801-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number.

CE 4811-4823. Special Topics
Credit hours equal last digit of course number.

CE 4900. Special Problems.
Credit hours to be arranged.

CE 6003. Construction Administration
2-3-3. Fall quarter.
Management tools used to carry out administrative aspects of construction project management. Estimating and bid control. Quantity takeoff procedures, cost accounting, insurance, bonding, finance, and safety.

CE 6013. Civil Engineering Management I
2-3-3. Corequisite: ISYE 6739. Winter quarter.
Scientific methods in the management of construction projects. Techniques such as C.P.M. and P.E.R.T. for planning, scheduling, and control of construction projects.

CE 6023. Civil Engineering Management II
2-3-3. Prerequisite: CE 6013. Corequisite: ISYE 6734. Spring quarter.
Continuation of CE 6013. Additional topics include linear and dynamic programming, queueing models and simulation as applied to construction project management.

CE 6051. Intermediate Fluid Mechanics I
3-0-3. Prerequisite: CE 3054. Fall quarter.
Basic analytical techniques of fluid mechanics; kinematics and dynamics of fluid flows; conservation of mass, momentum, and energy; Bernoulli and Navier-Stokes equations; potential flow.

CE 6052. Intermediate Fluid Mechanics II
3-3-4. Prerequisite: CE 6051. Winter quarter.
Low Reynolds number flow. Turbulent flow. Laminar and turbulent boundary layers, boundary layer controls. Lift and drag, cavitation.

CE 6054. Engineering Hydrodynamics
3-0-3. Prerequisites: CE 6051, MATH 4320. Fall quarter.
Irrotational flow, potential and stream functions, principles of continuity, energy, and momentum. Hydrodynamic singularities, conformal transformations, discontinuous flows, and free-stream-line solutions. Analytic and approximate methods.

CE 6061. Environmental Fluid Mechanics I
3-0-3. Prerequisite: CE 3054. Spring quarter.

Basic analytical techniques for predicting pollutant transport in various hydrologic situations. Diffusion in laminar and turbulent flows and shear flows. Mechanics of jets and plumes.

CE 6062. Environmental Fluid Mechanics II
2-3-3. Prerequisite: CE 6061. Summer quarter.
Practical application of basic principles to engineering situations. Mixing in rivers, lakes, reservoirs, estuaries; the use of numerical and physical models.

CE 6071. Flow Through Porous Media I
3-0-3. Prerequisite: CE 6051. Spring quarter.
Darcy's Law and fundamental equations of groundwater flow. Mathematics models and analytical solutions to elementary groundwater flow problems. Basic concepts of unsaturated flow and approximate methods.

CE 6072. Flow Through Porous Media II
3-0-3. Prerequisite: CE 6071. Summer quarter.
Fundamental equations of saturated-unsaturated groundwater flow. Mechanics of dispersion in groundwater flow. Multiphase flow. Approximate methods of solution.

CE 6081. Flow in Open Channels I
2-3-3. Prerequisites: CE 3054, 3061. Fall quarter.
Flow of liquids with free surfaces in natural and artificial channels. Application of energy and momentum principles, analysis of flow resistance, computation of gradually varied flow profiles.

CE 6082. Flow in Open Channels II
2-3-3. Prerequisite: CE 3054, 3061. Winter quarter.
Flow of liquids through open channel transitions and controls including weirs, free overfalls, spillways, expansions, contractions, and culverts. Analysis of steady, spatially varied flow and treatment of unsteady flow in open channels.

CE 6084. Transient Flow in Enclosed Conduits
2-3-3. Prerequisite: CE 3054. Spring quarter.
Unsteady flow of compressible and incompressible fluids in conduits, pressure wave propagation, one-dimensional wave equations, method of characteristics, pulsating flow, water hammer, hydraulic machinery, column separation.

CE 6086. Sediment Transport
3-0-3. Prerequisite: CE 3054. Spring quarter.
Sediment properties, initiation of sediment motion by flowing water, suspended sediment discharge, bed load discharge, bed form mechanics, hydraulic resistance to flow. Reservoir sedimentation.

CE 6091. Coastal Engineering
3-0-3. Prerequisite: CE 6051. Winter quarter.
Application of hydrodynamic principles to coastal zones: mechanics of wave motion, wave refraction, diffraction and reflection, equilibrium theory of tides, harbor resonance, harmonic analysis of waves and tides.

CE 6102. Physical Principles in Environmental Engineering
4-0-4. Prerequisite: consent of the instructor. Fall quarter.
Analysis of the physical principles of water quality control, such as sedimentation, flocculation, filtration, inertial separation, gas transfer, and principles of reactor design.

CE 6103. Aquatic Chemistry
3-0-3. Prerequisite: CE 6136. Spring quarter.
Chemical behavior of natural aquatic systems: lakes, oceans, rivers, estuaries, groundwater, waste water, treatment systems. Analysis of natural waters using physical chemistry principles.

CE 6105. Application of Instrumental Analysis in Environmental Engineering
2-3-3. Prerequisites: CE 6136, 6137. Winter quarter.
Theory, design, sensitivity, and limitations of environmental sampling instruments. Spectrophotometric, electromechanical, and gas chromatograph analysis of solid waste, water, and waste water.

CE 6109. Environmental Engineering Design I
3-3-4. Prerequisite: consent of the instructor. Spring quarter.
Theory and design of structures for capture, purification, conditioning, and distribution of public water supplies.

CE 6115. Hazardous Waste Management
2-3-3. Prerequisite: consent of the instructor. Summer quarter.
Introduction to hazardous waste management with special emphasis on identification of sources, characteristics, transportation requirements, and treatment and disposal methods.

CE 6116. Environmental Engineering Processes Laboratory
1-6-3. Prerequisites: CE 6140, 6141, and 6142. Summer quarter.
Laboratory evaluation of various physical-chemical and biological processes that form the basis of many water quality control operations, including coagulation, thickening, adsorption, gas transfer, membrane separations, filtration, dewatering, and biological oxidation.

CE 6118. Solid Waste Technology I
2-3-3. Prerequisite: consent of the School. Winter quarter.
An introduction of the fundamentals of solid waste characterization, handling and disposal systems, physical and chemical methods of solid waste analysis.

CE 6119. Environmental Engineering Design II
3-3-4. Prerequisite: consent of the instructor. Summer quarter.
Theory and design of structures for collection, treatment, disposal, and reuse of municipal sewage and liquid industrial wastes.

CE 6120. Treatment and Disposal of Residues
3-0-3. Prerequisite: consent of the instructor. Spring quarter.
Characterization, stabilization, conditioning, thickening, dewatering, conversion, recovery, transportation, and disposal of air, water, and waste water treatment residues.

CE 6125. Industrial Waste Treatment and Disposal
3-0-3. Prerequisite: consent of the instructor. Spring quarter.
Evaluation of industrial waste problems, characteristics of wastes produced from industry, and application of engineering principles and processes for waste treatment, recovery, and disposal.

CE 6126. Introduction to Air Pollution
3-0-3. Winter quarter.
Sources of primary and secondary air pollution. Application of thermodynamics and kinetics to production of air pollutants from combustion processes and atmospheric photochemical reactions. Dispersion and control.

CE 6127. Analysis of Air Pollutants
2-3-3. Spring quarter.
Principles of air sampling and sampling trains. Techniques of sampling inorganic gases and aerosols. Evaluation of data.

CE 6128. Solid Waste Technology II
2-3-3. Prerequisite: CE 6118. Spring quarter.
Evaluation of typical solid waste problems, application of fundamental principles to design and management, case studies of operational solid waste systems, new methods, advanced topics.

CE 6130. Environmental Processes in Surface Water Systems
3-0-3. Prerequisite: CE 4118. Winter quarter.
Analysis of chemical, physical, and biological processes occurring in natural water systems such as streams, lakes, and estuaries.

CE 6136. Applications of Chemistry in Environmental Engineering
3-0-3. Prerequisite: consent of the instructor. Fall quarter.
Kinetic and equilibrium relationships controlling the chemical behavior of the aquatic environment. Distribution and behavior of chemical species in dilute aqueous systems.

CE 6137. Fundamentals of Chemical Analysis in Environmental Engineering
1-3-2. Corequisite: CE 6136. Fall quarter.
Basics of wet chemical analysis of aqueous samples. Titrametric and spectrometric techniques of importance in sanitary and environmental engineering as well as general laboratory methods.

CE 6138. Applied Limnology
2-3-3. Spring quarter.
Consideration and application of limnological principles as they pertain to evaluating the impact waste water disposal will have on the biological productivity of inland waters.

CE 6140. Environmental Engineering Processes I
4-0-4. Prerequisites: CE 3054, 4118, 6102, and 6136. Winter quarter.
Theory and application of the physical and chemical processes of coagulation, flocculation, sedimentation, and filtration in water and waste water treatment.

CE 6141. Environmental Engineering Processes II
4-0-4. Prerequisites: CE 4118, 4148, 6102, and 6136. Winter quarter.
Study of biological and chemical processes employed in water and waste water treatment systems. Biological growth kinetics, biological reactor configuration including activated sludge, trickling filters, lagoons, and oxidation ponds.

CE 6142. Environmental Engineering Processes III
3-0-3. Prerequisite: CE 6102. Spring quarter.

Advanced treatment processes in environmental engineering, including membrane separation, adsorption, and ion exchange.

CE 6146. Field Methods in Environmental Engineering
0-15-5. Summer quarter.
Organization and conduct of water quality surveys and field studies for natural waters.

CE 6148. Advanced Microbiology of Water and Wastes
2-3-3. Prerequisite: CE 4148. Winter quarter.
Microbial growth in water and waste treatment systems, enrichment cultures, and their application in process design. Respiratory mechanisms and fermentations in waste treatment and stream pollution.

CE 6153. Dock, Harbor, and Shore Structures
3-0-3. Prerequisite: CE 4214. Spring quarter.
Function, design, and construction of marine structures such as docks, bulkheads, dry docks, breakwaters, channels, and shore protection works.

CE 6154. Advanced Soil Mechanics
3-3-4. Prerequisite: CE 4163. Winter quarter.
Flow of water through soil and rock, design of drainage systems, earth dams, and dam foundations. Elastic and plastic equilibrium applied to problems of slope stability.

CE 6159. Rock Mechanics
3-3-4. Prerequisite: CE 4163. Spring quarter.
Mechanics of rock masses and influence of geologic features on their engineering properties. Discussion of relevant tests for determination of both in-situ and laboratory properties of rocks.

CE 6163. Physical and Physiochemical Properties of Soils
3-0-3. Prerequisite: CE 4154. Fall quarter.
Formation of soils, physical chemistry of soil minerals and soil water, consolidation, swell, shrinkage, shear strength, and related phenomena, geology of soil deposits.

CE 6164. Advanced Foundation Engineering
3-3-4. Prerequisite: CE 4163. Spring quarter.
Analysis and design of foundations, bearing capacity and settlement theory. Analysis of pile and continuous foundations, theories of earth pressure, design of earth-retaining structures.

CE 6172. Soil Testing
1-3-2. Prerequisite: CE 6194. Winter quarter.
Theory of physical testing of soils for engineering design and research, laboratory exercises in consolidation and shear testing, illustrations of test procedure effects on character of data.

CE 6173. Terrain Evaluation and Applications
2-3-3. Prerequisite: CE 4163. Fall quarter.
Structure of soil and rock formations and their reflection in the terrain. Analysis of terrain features by aerial photographs and other forms of remote sensing.

CE 6183. Soil Construction
2-3-3. Corequisite: CE 4154. Fall quarter.
The migration of soil moisture, frost action, compaction, soil stabilization, evaluation of subgrades and bases for pavements.

CE 6184. Soil Stabilization and Site Improvement
3-0-3. Summer quarter.
Mechanical, chemical, and reinforcing methods for improving the engineering properties of soil used as a construction material or used to support foundations.

CE 6193. Dynamics of Massive Media
2-3-3. Summer quarter.
Introduction to dynamics of massive media with applications to analysis of vibratory machine foundations and earthquake problems, including slope stability and liquefaction. Dynamic properties of soil and rock.

CE 6194. Theoretical and Applied Soil Mechanics I
4-0-4. Corequisite: CE 6163. Fall quarter.
Theories of elastic equilibrium of soil masses. Application to analysis of complex soil engineering problems such as stresses and settlements of soil, mat foundations, laterally loaded piles, and pile groups.

CE 6199. Theoretical and Applied Soil Mechanics II
4-0-4. Prerequisite: CE 6194. Winter quarter.
Theories of plastic equilibrium of soil masses, application to analysis of complex soil engineering problems. Pressures on earth retaining structures, anchored bulkheads, laterally loaded piles, and earth anchors.

CE 6203. Structural Planning
3-0-3. Prerequisite: CE 3224. Spring and summer quarters.
Introduction to planning aspects of structural design, economic proportions, erection procedures, comparison of determinate and indeterminate structures, stress control, normal and hybrid behavior.

CE 6204. Reinforced Concrete Structures I
4-0-4. Prerequisite: CE 4214. Fall quarter.
Review of working stress methods, analysis and design procedures based on ultimate load capacity, effects of creep, shrinkage, and temperature, torsional stresses and reinforcing, deflections.

CE 6209. Reinforced Concrete Structures II
4-0-4. Prerequisite: CE 6204. Winter quarter.
Principles and practice of prestressed concrete, systems and techniques for applying prestress, analysis and design of determinate and indeterminate prestressed concrete structures, ultimate strength behavior.

CE 6213. Experimental Analysis I
3-0-3. Winter quarter.
Data acquisition from models. Stress analysis through strain measurements. Transducers, their circuitry and related indicating and recording equipment. Motion measurement, equivalent circuits.

CE 6214. Indeterminate Structural Theory I
4-0-4. Prerequisite: CE 3224. Fall quarter.
Study of principles and fundamental theorems of structural analysis with applications to indeterminate structures: beams, frames, and trusses.

CE 6219. Matrix Methods of Structural Dynamics
4-0-4. Prerequisites: CE 6229, 6248. Winter quarter.
Linear and nonlinear dynamic matrix analysis of multidegree-of-freedom structural systems. Substructuring techniques. Analysis and design for wind and earthquake. Computer programming.

CE 6229. Principles of Matrix Structural Analysis
4-0-4. Prerequisite: CE 3224. Fall quarter.
Matrix formulation of the governing equations of framed structures, linear elastic behavior, physical and geometrical nonlinearities, force and displacement methods, nonlinear analysis.

CE 6234. Advanced Structural Mechanics
4-0-4. Prerequisite: MATH 2308. Winter quarter.
Study of advanced topics from mechanics of materials with application to civil engineering structures. Typical topics: generalized stress and strain, failure theories, torsion, shear flow, buckling, fatigue.

CE 6238. Finite Element Method of Structural Analysis
3-0-3. Prerequisite: CE 6229. Spring quarter.
Introduction to finite element method, matrix formulation. Plates in plane stress, plane strain, and bending. Three-dimensional solids and shells. Static and dynamic, linear and nonlinear analysis.

CE 6244. Plastic Design in Steel
4-0-4. Prerequisite: CE 4204. Spring quarter.
Analysis and design procedures based on ultimate load capacity are applied to steel beams, frames, and their connections.

CE 6248. Structural Dynamics
3-0-3. Prerequisite: consent of the School. Fall quarter.
Vibration and dynamic response of simple linear and nonlinear structures to periodic and general disturbing forces. Response analysis of multidegree-of-freedom systems. Wind and earthquake effects.

CE 6249. Reinforced Concrete Structures III
4-0-4. Prerequisites: CE 6209, MATH 2308. Spring quarter.
Analysis and design of slab and thin-shell structures, additional applications of prestressing, yield-line theory, shells of revolution, cylindrical shells, folded plates, hyperbolic paraboloids, prestressed tanks.

CE 6250. Earthquake Engineering
3-0-3. Prerequisite: CE 6248. Summer quarter.
Analysis and design of civil engineering structures for earthquake resistance; building code requirements; case studies.

CE 6273. Legal Principles of Land Surveying
2-3-3. Prerequisite: CE 2264.
History and development of legal principles controlling boundary location of real property. Writing, interpreting, and locating deed descriptions.

CE 6303. Pavement Design
3-0-3. Prerequisites: CE 4304, 4154. Spring quarter.
Theory of flexible and rigid pavement behavior, stress condition and deflection, climate, pavement design methods, and evaluation of pavement performance.

CE 6305. Advanced Transportation Planning
2-3-3. Prerequisite: CE 6344.
Examination of advanced methods and problems in transportation planning, land use models, the Urban Transportation Planning System (UTPS), and evaluation of transportation plans; computer modeling.

CE 6308. Concrete Technology
2-3-3. Prerequisites: CE 3309, 4214. Winter quarter.
Design theories for concrete mixes, mixes for specific conditions of workability, density, strength, admixtures and air entrainment. Preparation and testing of concrete mixtures, minor research in concrete.

CE 6313. Airport Planning and Design
2-3-3. Prerequisite: CE 4304. Fall quarter.
Airport site selection, runway length and orientation, traffic control, drainage and lighting, long-range planning, government responsibility for air transportation.

CE 6315. Computerized Traffic Surveillance and Control
3-0-3. Prerequisite: CE 6333.
Real-time monitoring and control of traffic on streets and freeways. Detectorization, computer strategies and software, communications, signals, implementation. TRANSYT program for optimal signal timing.

CE 6318. Asphalt Technology
2-3-3. Prerequisite: CE 4313, 4154. Fall quarter.
Theory of asphalt mix design. Preparation of asphaltic mixes for stability, durability, economy. Use of various materials and grades of asphalt in bituminous concrete pavements.

CE 6323. Transportation Administration
2-3-3. Fall quarter.
Advanced study of national transportation policies, financial problems, administrative procedures relating to development of transportation facilities.

CE 6328. Mass Transit Planning
3-0-3. Prerequisite: consent of the School. Spring quarter.
Characteristics and costs of present and innovative mass transit systems. Roles of engineer, planner, and others in estimating transit usage and choosing optimal plan.

CE 6333. Traffic Engineering
2-3-3. Prerequisite: CE 4304. Fall quarter.
Characteristics of drivers and vehicles, traffic studies, capacity, signal systems, engineering solution of traffic movement problems. Supervised traffic engineering studies.

CE 6338. Advanced Traffic Operations
2-3-3. Prerequisite: CE 6333. Winter quarter.
Application of traffic control devices to improve capacity, safety of urban street systems. Emphasis on computer control of signal systems, application of computer simulation models.

CE 6343. Design of Highways and Transit Facilities
2-3-3. Prerequisite: CE 6333. Spring quarter.
Geometric configurations of streets, expressways, busways, railways, and their terminals to meet characteristics of vehicle performance and operator limitations.

CE 6344. Urban Transportation Planning
3-3-4. Prerequisite: CE 6333. Winter quarter.
Planning of urban transportation facilities, mathematical models for prediction of traffic flow, assignment, interrelationship of land use and trips, parking and the transportation problem.

CE 6353. Economic and Financial Aspects of Public Works Planning
3-0-3. Fall quarter.

Discounting techniques for public works planning. Microeconomics in project formulation. Applications from welfare economics, capital formation theory, input-output analysis.

CE 6363. Economics of Water Resources Development
2-2-3. Prerequisite: CE 6353. Winter quarter.
Principles of resource allocation, benefit-cost analysis, water-resources project formulation, justification, allocation of joint costs in multipurpose developments.

CE 6371. Statistical Hydrology
2-3-3. Prerequisite: consent of the instructor. Winter quarter.
Probability distributions applicable to hydrologic events; analysis of extreme events, floods and droughts, regression and correlation analysis of hydrologic variables.

CE 6372. Stochastic Hydrology
3-0-3. Prerequisite: CE 6371. Spring quarter.
Stochastic modeling of hydrologic processes. Problems of model specification, parameter identification, and validation. Application to forecasting and synthetic events.

CE 6373. Flood Management
3-0-3.
Hydrology and hydraulics of flood management measures. Analysis of flood control and flood damage abatement: levees, floodways, channel improvements, reservoirs.

CE 6374. Physical Hydrology
3-0-3. Prerequisite: CE 4353. Fall quarter.
Study of physical processes governing occurrence, movement, and distribution of water; atmospheric transport processes and circulation; precipitation; evaporation; transpiration; snowmelt; infiltration; groundwater flow; and catchment morphology.

CE 6381. Watershed Models I
3-0-3. Prerequisite: CE 4353. Winter quarter.
Development of deterministic watershed simulation concepts including surface runoff, overland flow, streamflow, flood routing, reservoir routing. Linear catchment models. Data preparation techniques for watershed models.

CE 6382. Watershed Models II
2-3-3. Prerequisite: CE 6381. Spring quarter.
Characterization of existing deterministic watershed simulation models, model selection, calibration techniques, simulation techniques. Students will calibrate several representative models to measured data.

CE 6384. Urban Hydrology
3-0-3. Prerequisite: CE 4353. Spring quarter.
Effects of urbanization on storm runoff, sedimentation, water quality, and water supply. Modeling of urban runoff. Urban watershed in planning and design. Legal, institutional, and economic framework.

CE 6399. Water Resources Systems I
3-0-3. Prerequisite: ISYE 6734 or equivalent, or consent of the instructor. Spring quarter.
Review and application of operations research methodologies, including classical optimization, linear programming, nonlinear programming and dynamic programming, to planning and design of water resource systems.

CE 6513. Probability in Civil Engineering Design
3-0-3. Prerequisite: CE 3534. Spring quarter.
Outlines the extent of uncertainties under which civil engineering designs and decisions are made. Theory and application. First step toward developing a risk-based design format.

CE 6518. Risk Analysis and Decision Theory in Civil Engineering
3-0-3. Prerequisite: CE 6513. Summer quarter.
Advanced topics in risk-based engineering design. Methods available, advantages, and disadvantages. System reliability concepts. Statistical decision theory and its application in civil engineering.

CE 6772. Advanced Computer Interfacing and Design
2-3-3. Prerequisite: NE 6770. Spring quarter.
A study of system design using MSI and LSI chips and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

CE 6773. Computer Control of Real-time Systems
3-3-4. Prerequisites: NE 6770, EE 4077 or equivalent. Summer quarter.
A study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectored interrupts, and statistical alarm conditions.

CE 6775. Advanced Engineering Programming Methods
3-3-4. Prerequisite: CE 3513 or equivalent. Summer quarter.
Advanced engineering programming concepts and their implementation on large-scale digital computers. Dynamic data, dynamic programs, engineering data management, engineering problem-oriented language development and ICES.

CE 7000. Master's Thesis
Credit hours to be arranged.

CE 7999. Doctoral Examinations Preparation
Credit hours to be arranged.
For students preparing for the doctoral qualifying examination.

CE 8002. Seminar in Environmental Engineering
0-2-1.
Developments in environmental engineering science and technology, current research, and special topics related to environmental quality assessment and control.

CE 8003. Research Seminar in Environmental Engineering
1-0-1. Prerequisites: CE 4148, CE 6136, and graduate status.
Discussions of current research topics in environmental engineering. Emphasis on critical in-depth review of published research results and those presented by doctoral students.

CE 8031. Seminar in Soil and Rock Mechanics
0-2-1. Corequisites: CE 6154 and consent of the School. Winter quarter.
Case histories of design and construction problems involving soil and rock mechanics, including excavations, drainage, dams, retaining structures, and slope stability.

CE 8041. Seminar in Foundation Engineering
1-0-1. Prerequisite: CE 6154. Corequisite: CE 6164. Spring quarter.
Case histories of design, construction, and performance of foundations. Special topics such as machine foundations, foundations in seismic regions.

CE 8051. Seminar in Transportation Engineering
1-0-1. Prerequisite: consent of the School. Winter quarter.
Developments in the design and planning of traffic engineering and transportation systems, impact of current literature, and technology on the field.

CE 8061. Construction Seminar
0-2-1. Corequisite: CE 6003.
Engineered construction. Whenever possible, guest speakers from the construction industry. Graduate students will present results of required special research projects and thesis research.

CE 8071-81-91. Seminar in Hydraulics, Fluid Mechanics, and Hydrology
1-0-1 each. Fall, winter, and spring quarters.
Presentation and discussion of research developments, current research topics, and graduate student research in hydraulics, fluid mechanics, and hydrology.

CE 8101-2-3-4-5. Special Topics
Credit hours equal last digit of course number.

CE 8113-4-23. Special Topics
Credit hours equal last digit of course number.

CE 8500-1. Special Problems
Credit hours to be arranged.

CE 8756. Master's Special Research Problem
Credit hours to be arranged.
Six to twelve hours of master's research problem to be scheduled by master's students not writing thesis during two or more successive quarters.

CE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

CE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

CE 8999. Doctoral Thesis Preparation
Credit hours to be arranged.
For student in preliminary stages of formulating doctoral research program who has not obtained formal approval of thesis topic.

CE 9000. Doctoral Thesis

ENGINEERING GRAPHICS

EGR 1170. Introduction to Visual Communication and Engineering Design
2-3-3.
Theory and application of the design process, assigned design project and report. Elements of projection theory that enhance ability to communicate graphically.

ENGINEERING SCIENCE AND MECHANICS

ESM 1101. Introduction to Engineering
1-6-3.
The engineer and design, relation between the student's curriculum and his or her career in engineering. Emphasis placed on student participation in creative design process.
Text: at the level of Beakley and Leach, *Engineering: An Introduction to a Creative Profession.*

ESM 2101. Engineering Design I
0-3-1. Prerequisite: ESM 1101 or consent of the School.
Study of a problem that arises from a need of society. Proposals for a creative solution studied to select best design. Substitution permissible for co-ops.

ESM 2102. Engineering Design II
0-6-2. Prerequisite: ESM 2101.
Continuation of ESM 2101. Solution of design problem to be completed, a model to be submitted as part of final report.

ESM 2201. Statics
3-0-3. Prerequisite: PHYS 2121. Prerequisite or corequisite: MATH 2307.
Elements of statics in two and three dimensions, centroids, analysis of structures and machines, friction.
Text: at the level of McGill and King, *Statics.*

ESM 3111. Experimental Methods in Engineering Science and Mechanics
2-3-3. Prerequisites: EE 3400, MATH 3308, ESM 3201, 3301, ENGL 3020.
Methods used to observe behavior of physical parameters in engineering problems, photo-optics, signal analysis, transducers and transducer circuits, models and analogies.
Text: at the level of Tuve and Domholdt, *Engineering Instrumentation.*

ESM 3112. Bioengineering Measurements
3-0-3. Prerequisite: junior standing in engineering or consent of the instructor.
Medical diagnostic procedures are described after studying the relevant physiology and the applied engineering principles.
Text: at the level of Cromwell, Weibell, and Pfeiffer, *Biomedical Instrumentation and Measurements.*

ESM 3201. Dynamics I
3-0-3. Prerequisites: ESM 2201, MATH 2307.
Kinematics and kinetics of rigid bodies in plane motion.
Text: at the level of McGill and King, *An Introduction to Dynamics.*

ESM 3202. Dynamics II
3-0-3. Prerequisite: ESM 3201.
Kinematics and kinetics of three-dimensional motion of rigid bodies.
Text: at the level of McGill and King, *An Introduction to Dynamics.*

ESM 3301. Mechanics of Deformable Bodies
5-0-5. Prerequisite: ESM 2201. Pre- or corequisite: MATH 2308.
Definition and analysis of strain and stress, applications to axially loaded elements, torsion or circular shafts and bending of beams, introduction to simple plasticity and to column stability.
Text: at the level of Popov, *Introduction to the Mechanics of Solids.*

ESM 3302. Mechanics of Materials
3-0-3. Prerequisite: ESM 3301.
Analysis and design of various structural elements, unsymmetrical bending, shear center, energy methods. Open-ended problems.

ESM 3451. Computer Applications in Engineering Science and Mechanics
2-3-3. Pre- or corequisite: ESM 3302, 3501, 4210, or consent of School.
Introduction to the use of the digital computer. FORTRAN languages, computer solutions of problems in statics, dynamics, mechanics of deformable solids, vibrations, and fluid mechanics.

ESM 3452. Microcomputers in Engineering Science
3-0-3. Prerequisite: junior standing.
An introduction to microcomputers emphasizing laboratory applications in the engineering sciences; data conversion and display control of experiments. Project in areas of robotics, digital control, speech synthesis, and others.

ESM 3501. Fluid Mechanics
5-0-5. Prerequisites: MATH 3308 and ESM 3202.
Control volume analysis and similitude. Development and solution of the governing equations of viscous and inviscid fluid flow. Introduction to turbulence and boundary layers.
Text: at the level of Owczarek, *Introduction to Fluid Mechanics.*

ESM 3750. Introduction to Biofluid Dynamics
3-0-3. Prerequisite: MATH 3308, PHYS 2123, or consent of the instructor.
Introduces students to the study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research application. Also taught as AE 3750 and CHE 3750.

ESM 3901 through 3909. Special Problems in Engineering Science and Mechanics
Credit to be arranged. 3 hours maximum. Prerequisite: junior standing.
Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

ESM 4111. Introduction to Experimental Stress Analysis
1-6-3. Prerequisites: ESM 3301 or equivalent, senior standing.
Plane stress analysis using transmitted light photoelasticity and photoelastic models, study of surface strain using resistance strain gauges, transducer design and application.
Text: at the level of Holister, *Experimental Stress Analysis.*

ESM 4122. Project in Engineering Science and Mechanics I
0-3-1. Prerequisite: senior standing in engineering science and mechanics.

Through discussions with the faculty adviser and other members of the faculty, students will determine the design-related engineering problem they wish to study. A detailed written project proposal will be submitted to and approved by the student's faculty project adviser prior to the end of the quarter.

ESM 4123. Project in Engineering Science and Mechanics II
0-6-2. Prerequisite: ESM 4122.

Continuation of ESM 4122. Student will complete an experimental and/or a theoretical investigation of an engineering problem and submit a written report for the approval of his/her faculty project adviser.

ESM 4201. Intermediate Dynamics I
3-0-3. Prerequisite: ESM 3202 or consent of the School.

Kinematics and kinetics of particles and particle systems, applications include motion in resisting medium, redistribution of mass, central force motion, effects of earth rotation.

Text: at the level of Marris and Stoneking, *Advanced Dynamics*.

ESM 4202. Intermediate Dynamics II
3-0-3. Prerequisite: ESM 4201 or consent of the School.

Two- and three-dimensional motion of a rigid body, Euler's equations, introduction to energy methods, and Lagrange's equations.

ESM 4210. Mechanical Vibrations I
3-0-3. Prerequisites: ESM 3201, 3301 and MATH 3308 or their equivalent.

Single degree-of-freedom system, two degree-of-freedom system, and finitely many degrees-of-freedom system, complex representation, applications.

Text: at the level of Timoshenko, Young, Weaver, *Vibration Problems in Engineering*.

ESM 4211. Mechanical Vibrations II
3-0-3. Prerequisites: ESM 4210 and ESM 3302 or equivalent. Fall quarter.

Complex representation, step and impulse loads, many degrees of freedom, influence coefficients, matrix methods, stability of solution, vibrations of strings, beams and membranes, approximate methods.

Text: at the level of Timoshenko, Young, Weaver, *Vibration Problems in Engineering*.

ESM 4301. Mechanics of Deformable Bodies
3-0-3. Prerequisite: ESM 3301.

Small strain linear elasticity in two and three dimensions, applications in generalized plane stress and plane strain, torsion and bending of noncircular prisms.

ESM 4302. Stress Analysis
3-3-4. Prerequisite: ESM 4301.

Continuation of ESM 4301, further treatment of torsion and bending, strain energy, introduction to thin plates and simple shells, approximation methods.

ESM 4351. Continuum Mechanics
3-0-3. Prerequisites: MATH 3308, ESM 3301.

Geometrical foundations, analysis of stress and deformation, balance laws, constitutive equations, finite and infinitesimal elasticity.

ESM 4452. Biomechanics
3-0-3. Prerequisites: MATH 3308 or equivalent, ESM 3301 or equivalent.

The mechanics of living tissue, e.g., arteries, skin, heart muscle, and bone. Constitutive equations for tissues and some simple mechanical models. Biomechanical instrumentation.

ESM 4453. Biosystems Analysis
3-0-3. Prerequisite: MATH 3308 or equivalent.

Different analytical methods for modeling biological systems are described, including a white-noise protocol for characterizing nonlinear systems.

Text: at the level of Marmarelis and Marmarelis, *Analysis of Physiological Systems*.

ESM 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.

Acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as AE 4760, ME 4760.

ESM 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: ESM 4760 or equivalent.

Continuation of ESM 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as AE 4761, ME 4761.

ESM 4770. Structural Integrity and Durability
3-0-3. Prerequisite: ESM 3301 or AE 2101.

Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep, and relaxation. Introduction to fatigue and fracture mechanics. Crack-growth calculations and wearout models. Also taught as AE 4770.

ESM 4801 through 4809. Special Topics in Engineering Science and Mechanics
1-0-1 through 9-0-9, respectively. Prerequisite: senior standing.

Special courses not included in regular course offerings.

ESM 4901 through 4909. Special Problems in Engineering Science and Mechanics
Credit to be arranged. 3 hours maximum. Prerequisite: senior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty advisor.

ESM 6111. Theory of Experimental Stress Analysis
2-3-3. Prerequisite: ESM 3301 or consent of the School. Spring quarter.

Study of surface stress and strain using brittle coatings and strain gauges. Electrical resistance cemented and welded strain gauges, strain gauge circuits, static and dynamic problems, transducer design and circuits. Vibrating wire strain gauges. Application of failure theories.

ESM 6117. Experimental Photomechanics I
2-3-3. Prerequisite: ESM 3301 or equivalent. Fall quarter, odd years.

Polarized light, mathematical description, light transformations, photoelastic models, use of transmitted light for stress analysis in two-dimensional problems, birefringent coatings.

ESM 6118. Experimental Photomechanics II
2-3-3. Prerequisite: ESM 6117. Winter quarter, odd years.

Three-dimensional photoelastic stress analysis using transmitted light and scattered light methods, numerical methods, Moire fringes, holographic interferometry.

ESM 6201. Advanced Dynamics I
3-0-3. Prerequisites: ESM 4210 and MATH 3308, or equivalent. Fall quarter.

Kinematics and kinetics of particles, angular velocity, inertia properties, rigid body dynamics, generalized coordinates and forces, nonholonomic systems, solutions by vector methods and Lagrange's equations.

ESM 6202. Advanced Dynamics II
3-0-3. Prerequisite: ESM 4202 or 6201. Winter quarter.

A continuation of ESM 6201. Hamilton's principle, Hamilton's canonical equations, energy and momentum integrals, Hamilton-Jacobi theory, study of selected papers from recent dynamics literature.

ESM 6221. Vibrations I
3-0-3. Prerequisite: MATH 4582 or consent of the School. Fall quarter.

Lagrange's equations, small oscillations of conservative and nonconservative systems, natural modes; response of multidegree-of-freedom systems; introduction to vibration of continuous systems.

ESM 6222. Vibrations II
3-0-3. Prerequisite: ESM 6221, 6321, or 6341. Winter quarter.

Free and forced longitudinal, torsional, and lateral vibration of bars; vibration of membranes, plates, shells, and extended elastic bodies; approximate methods.

ESM 6223. Wave Propagation in Solids
3-0-3. Prerequisite: ESM 6222 or consent of the School. Spring quarter.

Wave propagation in elastic solids; dilatational equivolumnal and surface waves, reflection and refraction; waves in structural elements; analysis of impact problems.

ESM 6241. Gyroscopic Motion and Devices
3-0-3. Prerequisite: ESM 6201 or equivalent. Spring quarter, odd years.

Motion of a rigid body about a fixed point, the top, precession and nutation of the earth, the gyrocompass, rate and integrating gyros, the monorail, ship stabilizers.

ESM 6261. Space Mechanics I
3-0-3. Prerequisite: graduate standing. Fall quarter, even years.

The two-body problem, Kepler's equation, transfer orbits, Hohmann transfer, dynamics of rocket motion, rocket staging.

ESM 6262. Space Mechanics II
3-0-3. Prerequisite: ESM 6261 or consent of the School. Winter quarter, even years.

Celestial sphere, aberration, parallax, Laplace's and Gauss' methods, three- and n-body problems, Lagrangian points, Lagrange brackets, perturbations of an oblate planet, and atmospheric drag.

ESM 6281. Random Vibrations I
3-0-3. Prerequisites: MATH 4215 and ESM 4210, or consent of the School. Fall quarter, even years.

Statistical analysis of mechanical systems, correlation function, power spectral density, response to random inputs, method of normal modes, fatigue failures, nonstationary inputs, vibration of beams.

ESM 6282. Random Vibrations II
3-0-3. Prerequisite: ESM 6281. Winter quarter, even years.

Continuation of ESM 6281. Advanced engineering problems in random theory, nonstationary random inputs and response, measurement of power spectra, Fokker-Planck techniques, nonlinear systems.

ESM 6301. Advanced Strength of Materials
3-0-3. Prerequisites: MATH 3308, ESM 3301. Summer quarter.

Shear centers for beams, analyses of stresses and deflections in unsymmetrical bending, stresses and deflections in curved flexural members, beams on elastic supports.

ESM 6321. Applied Elasticity I
3-0-3. Prerequisite: ESM 3301 or equivalent. Fall quarter.

Analysis of stress and strain, stress-strain relations equilibrium, compatibility and boundary conditions, simple three-dimensional applications, plane elasticity problems in Cartesian and polar coordinates.

ESM 6322. Applied Elasticity II
3-0-3. Prerequisite: ESM 6321. Winter quarter.

Continuation of Applied Elasticity I, torsion and flexure of bars, introduction to thermoelasticity, finite-element, finite-difference approximations, and relaxation method as applied to elasticity problems.

ESM 6341. Theory of Elasticity I
3-0-3. Prerequisites: ESM 3301 and MATH 3308, or consent of the School. Fall quarter.

Introduction to generalized tensors, analysis of deformation, equations of motion, linearly elastic materials, formulation of the first, second and mixed boundary value problems.

ESM 6342. Theory of Elasticity II
3-0-3. Prerequisite: ESM 6341 or consent of the School. Winter quarter.

Continuation of ESM 6341, linear elasticity, Saint-Venant's theory of torsion, bending of beams, Love's strain function, Galerkin vector, Papkovich-Neuber representation, stress potentials, Airy's stress function.

ESM 6343. Theory of Elasticity III
3-0-3. Prerequisite: ESM 6342 or consent of the School. Spring quarter.

Continuation of ESM 6342; variational formulation of elasticity, energy theorems, introduction to thermo-elasticity, representation of biharmonic functions by analytic functions of a complex variable.

ESM 6361. Theory of Elastic Stability I
3-0-3. Prerequisites: ESM 3301 and MATH 4582, or consent of the School. Winter quarter.

Various stability methods and their applicability, the elastica problem, snap and bifurcation buckling, stability

of conservative systems, buckling of beams on elastic foundation, lateral buckling.

ESM 6362. Theory of Elastic Stability II
3-0-3. Prerequisite: ESM 6361 or consent of the School. Spring quarter.
Stability of various systems—velocity dependent, conservative, dissipative, circulatory, and nonstationary, with examples of each, recent developments in elastic stability theory.

ESM 6371. Theory of Plates
3-0-3. Prerequisites: graduate standing and MATH 4582 or equivalent. Spring quarter.
Von Karman theory of plates, pure bending of laterally loaded rectangular and circular plates, approximate methods, nonlinear considerations, stiffened and layered anisotropic plates.

ESM 6372. Theory of Shells
3-0-3. Prerequisite: ESM 6371 or consent of the School. Summer quarter.
Stresses and deformation of shells with and without bending under various loading conditions, shells forming surfaces of revolution, hyperbolic paraboloidal and elliptic paraboloidal shells.

ESM 6381. Plasticity
3-0-3. Prerequisite: ESM 6321 or 6341, or consent of the School. Spring quarter.
Stress-strain relations in three dimensions, three-dimensional yield conditions and flow laws, thick-walled tube and sphere, torsion of bars, slip line fields, technological processes, plates.

ESM 6391. Finite Elasticity
3-0-3. Prerequisite: ESM 4351 or consent of the School. Winter quarter.
Kinematics of finite deformation, stress, deformation and strain tensors, classical theory of finite elasticity for isotropic materials, introduction to simple materials.

ESM 6401-2. Optimization Techniques I and II
3-0-3 each. Prerequisite: graduate standing. Winter and spring quarters, even years.
Applications of calculus of variations to optimization of engineering systems and processes, end and corner conditions, discontinuous optimal processes, control and state variable inequality constraints, direct methods, etc.

ESM 6411. Energy Methods in Mechanics
3-0-3. Prerequisites: ESM 3301, MATH 4582 or consent of the School. Summer quarter.
' Virtual work, minimum total potential energy, minimum complementary energy, Castigliano's theorems, applications of calculus of variations, Rayleigh-Ritz method.

ESM 6450. Finite Elements, Boundary Elements, and Other Computational Methods in Mechanics I
3-0-3. Prerequisite: graduate standing in engineering. Fall quarter.
Review of weighted residual methods; linear solid and structural problems; finite element variational method-assumed displacement method; element interpolation, integration; assembly and solution of large systems of equations; convergence of finite element method; edge

function method; boundary elements methods, plane and 3-D elasticity.

ESM 6451. Finite Elements, Boundary Elements, and Other Computational Methods in Mechanics II
3-0-3. Prerequisite: ESM 6450 or consent of the instructor. Winter quarter.
Mixed and hybrid methods; assumed stress and multifield finite elements; combined finite elements and boundary elements; plate and shell problems; application to fracture—composites; finite deformation analysis; alternate stress and strain measures; objective stress rates-strain rates; finite element rate (incremental) methods.

ESM 6452. Finite Elements, Boundary Elements, and Other Computational Methods in Mechanics III
3-0-3. Prerequisite: ESM 6451 or consent of the instructor. Spring quarter.
Rate (incremental) analysis of finite strain problems; finite elasticity-finite strain elasto-plasticity; alternative variational rate finite element methods; stability; transient dynamic response; current developments in discrete approximations in fluid flow.

ESM 6461. Biosolid Mechanics
3-0-3. Prerequisite: ESM 4351 or equivalent.
Mechanics as applied to living tissues. Bioviscoelastic solids: the constitutive equations for blood vessels, muscles, cartilage, bone, and other tissues.

ESM 6501-2. Fluid Mechanics I and II
3-0-3. Prerequisite: graduate standing. Fall and winter quarters.
Mechanical principles of rational fluid mechanics. Kinematics, balance laws, examples of constitutive equations of fluids including perfect, Navier-Stokes, Rivlin-Ericksen fluids, potential flows, viscometric flows, introduction to approximate solutions and boundary-layer theory.

ESM 6751-2. Complex Systems Design I, II
2-4-3 each. Prerequisite: graduate standing in any school or senior with consent of the School. Winter and spring quarters.
Interdisciplinary team design of systems of current interest to society that have large technological factors. Individual research and interaction with nonuniversity resource persons and faculty. Grades based on oral and written reports. Cross-listed with ISYE and ME.

ESM 6760-1-2. Acoustics I, II, and III
3-0-3 each. Prerequisite: MATH 4349 or consent of the School. Fall, winter, and spring quarters.
Introductory analytical methods, and stochastic process, the wave equation in a compressible fluid, radiation of wind, reflection, refraction, diffraction and scattering of sound waves, duct acoustics. Also listed as AE 6760-1-2 and ME 6760-1-2.

ESM 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisite: ESM 6760, ESM 4760 or equivalent. Spring quarter.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as AE 6763, ME 6763.

ESM 6764. Ocean Acoustics
3-0-3. Prerequisite: GEOL 4300 or consent of the School. MATH 4321, 4582, ESM 6760 recommended. Spring quarter.
Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Also taught as GEOS 6764, ME 6764.

ESM 7000. Master's Thesis

ESM 7101-2-3-4-5. Master's Report
1-0-1 through 5-0-5, respectively. Prerequisite: consent of the adviser.
A theoretical and/or experimental investigation in a major area of interest to an M.S. candidate. Written report must be approved by faculty adviser. Required of all M.S. students not doing a thesis.

ESM 7201. Mechanics of Composite Materials
3-0-3. Prerequisite: ESM 6371, ESM 6321 or 6341, or consent of the instructor. Summer quarter.
Basic theory of anisotropic elasticity, equations for laminated composites, properties of laminates, estimation of the composite anisotropic moduli, bending, buckling and failure criteria of laminates.

ESM 7221. Nonlinear Vibrations I
3-0-3. Prerequisites: ESM 4210, 6201, and MATH 4582 or their equivalents. Winter quarter, odd years.
Vibrations of autonomous one-degree-of-freedom systems, method of approximated characteristics, topological methods, analysis of singularities and stability, free damped nonlinear vibrations, self-excited oscillations.

ESM 7222. Nonlinear Vibrations II
3-0-3. Prerequisite: ESM 7221. Spring quarter, odd years.
Nonlinear vibrations of nonautonomous one-degree-of-freedom systems, method of Duffing, perturbation method, Bogoliuboff method, Ritz-averaging method, stability criteria, subharmonics, two-degree-of-freedom systems.

ESM 7231. Wave Propagation in Continuous Media
3-0-3. Prerequisite: ESM 6501 or consent of the School. Fall quarter, odd years.
The theory of propagation of singular surfaces in three dimensions. Hadamard's lemma, Maxwell's theorem, compatibility conditions for weak singular surfaces, general balance at a singular surface, weak waves, applications to wave propagation in various materials.

ESM 7371. Stability of Shells
3-0-3. Prerequisites: ESM 6361, 6372. Fall quarter.
Linear and nonlinear theories for shell buckling, stability of thin stiffened and unstiffened plates and cylindrical shells under various loads, edge effects, imperfection sensitivity studies.

ESM 7501. Viscoelasticity
3-0-3. Prerequisites: ESM 6391, 6501 or consent of the School. Spring quarter.
The theory of viscoelasticity, simple fluids, viscoric flows, and the determination of material functions.

ESM 7511. Analytical Fracture Mechanics
3-0-3. Prerequisites: ESM 6321 or 6341 and MATH 4320 or equivalent. Spring quarter.

Half-plane problems. Symmetric crack problems. Crack-extension criteria. Antisymmetric crack problems. Williams' series. Effect of nearby boundaries. Crack growth under cyclic loading. Design problems.

ESM 7750. Biofluid Mechanics
3-0-3. Prerequisite: AE 6000 or ESM 6501, 6502 or consent of the instructor. Summer quarter.
A unified treatment on hemorheology, hemodynamics, pulsatile flows, microcirculation, joint lubrication, pulmonary physiology, etc., with emphasis on quantitative approach. Also listed as AE 7750.

ESM 7999. Preparation for Doctoral Qualifying Examination
Credit to be arranged. Prerequisite: consent of the adviser.

ESM 8001-2-3. Graduate Seminar
1-0-1 each.

ESM 8103-13-23-33-43-53. Special Topics
3-0-3. Prerequisite: consent of the adviser.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8104-14-24-34-44-54. Special Topics
4-0-4 each. Prerequisite: consent of the adviser.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8105-15-25-35-45-55. Special Topics
5-0-5 each. Prerequisite: consent of the adviser.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of the adviser.
Individual study and analysis of problems of current and future interest in engineering and science.

ESM 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

ESM 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

ESM 8999. Doctoral Thesis Preparation
Credit to be arranged.
For students in preliminary stages of formulating doctoral research program who have not obtained formal approval of thesis topic.

ESM 9000. Doctoral Thesis

School of Electrical Engineering
Established in 1896

Director and Professor—Demetrius T. Paris; *Associate Director and Georgia Power Distinguished Professor*—Roger P. Webb;

Associate Director for Graduate Affairs and Professor—Dale C. Ray; *Associate Director for Undergraduate Affairs and Professor*—Thomas M. White, Jr.; *Assistant to the Director for Laboratory Instruction*—Thomas E. Brewer; *Julius Brown Chair and Regents' Professor*—Thomas K. Gaylord; *John O. McCarty/Audichron Professor and Regents' Professor*—Ronald W. Schafer; *Schlumberger Professor in Microelectronics*—Phillip E. Allen; *Regents' Professors*—John W. Hooper, George P. Rodrigue, Kendall L. Su; *Professors*—Cecil O. Alford, Thomas P. Barnwell III, Henry C. Bourne, Jr., Aubrey M. Bush, J. Alvin Connelly, Atif S. Debs, Robert K. Feeney, Daniel C. Fielder, Abraham H. Haddad, Edward B. Joy, Richard P. Kenan, W. Marshall Leach, Jr., Russell M. Mersereau, John B. Peatman, William T. Rhodes, William E. Sayle II, Jay H. Schlag, Albert P. Sheppard, Jr., Glenn S. Smith, George J. Vachtsevanos, Carl M. Verber; *Associate Professors*—W. Russell Callen, Jr., Kent R. Davey, John F. Dorsey, Monson H. Hayes, David R. Hertling, Frank L. Lewis, Athan P. Meliopoulos, Mohamed F. Moad, Hans B. Puttgen, Ajeet Rohatgi, John P. Uyemura, Erik I. Verriest; *Assistant Professors*—Paul J. Benkeser, Kevin F. Brennan, Douglas W. Browning, John A. Buck, Mark A. Clements, James O. Hamblen, Joseph L. A. Hughes, Chin-Tau Lea, Alan Parker, David J. Schwartz, Waymond R. Scott, Jr., Mark J. T. Smith, Paul G. Steffes, Gordon L. Stuber, Yorai Wardi; *Laboratory Coordinator/Instructor*—Bruce McFarland; *Instructors*—Antoine Ayoub, Larry Coffeen, Clayton H. Griffin, Walter L. Hibble, Raymond Hill, Frank Lambert, Henry Owen; *Principal Research Scientist*—J. Lee Edwards; *Principal Research Engineers*—Donald G. Bodnar, N. Walter Cox, James D. Echard, Larry D. Holland, Richard C. Johnson, Edward K. Reedy, James C. Wiltse; *Senior Research Scientist*—Noberto Ezquerra; *Research Engineers I*—Timothy S. Floyd, Deborah Jackson, Wei-Siong Tan; *Research Engineers II*—Thomas R. Collins, Thomas C. Marsh, Stephen J. McGrath; *Research Associate II*—Irene G. Wells; *Research Technologist I*—Russell Beason, Jr.

General Information

Electrical engineers have pioneered the field of electronics, computers, control, power, and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy that can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively, even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language; exhibit logical thinking, creativity, curiosity, imagination, persistence, and patience; and demonstrate a mastery of mathematics, chemistry, and physics.

At the undergraduate level, a broad range of electives balances the basic required program of instruction in fundamental theory and laboratory practice. These electives are available in a wide variety of major areas such as speech processing, integrated circuits and systems, digital signal processing, fiber optics, applied electromagnetics, communications, computer engineering, solid-state electronics, and energy engineering. The student, with the counsel and guidance of faculty advisers, designs an elective program around his or her own special interests.

The graduate programs leading to the master's and doctoral degrees provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty or in a group of closely related specialties.

Graduate programs include computer engineering, digital signal processing, electric power engineering, electromagnetics, electronic design and applications, microelectronics, modern optics, systems and controls, and telecommunications. Multidisciplinary nondegree programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year. Full-time students can complete their master's program in one calendar year.

Housed in a modern facility, the School maintains a vigorous program of student-centered research conducted in well-equipped laboratories.

Additional information about the programs may be obtained from the School's grams may be obtained from the School's Student Handbook, available upon request or by calling the School at (404) 894-2900. Every student enrolled *must consult* this source of information concerning special rules and degree requirements.

Multidisciplinary Programs
See table on page 83.

Bachelor of Electrical Engineering Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
Humanities/Social Sciences/Modern Languages Electives	.....	3-0-3	3-0-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Freshman Engineering Elective	X-X-3	.....	.....
Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	X-X-3	.....	.....
TOTALS	X-X-19	X-X-16	X-X-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics I	.....	3-0-3	.....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3308 Differential Equations	.....	.....	5-0-5
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
EE 3200-50 Elements of Electrical Engineering I, II	.....	3-0-3	3-0-3
EE 3400 Instrumentation Laboratory	.....	.....	1-3-2
EE 3360 Digital Hardware	.....	.....	3-0-3
EE 3411 Junior EE Laboratory I	.....	.....	0-3-1
Humanities/Social Sciences/Modern Languages Electives	3-0-3	.....	3-0-3
Elective	3-0-3	.....	.....
TOTALS	18-3-19	15-3-16	15-6-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 3300-10-20 Electromagnetics	3-0-3	3-0-3	3-0-3
EE 3210-20 Circuits and Systems I, II	3-0-3	.....	3-0-3
EE 3215 Signals and Systems	.....	3-0-3	.....
EE 3260 Engineering Electronics	3-0-3	.....	.....
EE 3270 Nonlinear Devices and Circuits	.....	3-0-3	.....
EE 3330 Electromechanical Systems and Energy Conversion	.....	.....	3-0-3
EE 3421-31 Junior EE Laboratory II, III	.....	0-3-1	0-3-1
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Electives	4-0-4	4-0-4	4-0-4
TOTALS	16-0-16	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 4350 Materials Science	3-0-3	.....	.....
EE 4411-21 Senior EE Laboratory I, II	0-3-1	0-3-1	.....

EE 4430			
Project Laboratory	.....	.....	0-3-1
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Electives	10-0-10	13-0-13	13-0-13
TOTALS	16-3-17	16-3-17	16-3-17

REQUIREMENTS

Computer Requirement

Utilization of Institute computer facilities to solve engineering problems is required in the basic electrical engineering curriculum. Each student is expected, by means of formal course work, seminar attendance, or independent study, to acquire knowledge of basic programming in either FORTRAN or Pascal and in the use of Institute computing facilities prior to enrollment in EE 3200. Formal courses that provide the opportunity to acquire this knowledge are EE 1010, ICS 1410, ICS 1700, ICS 2101, and NE 1010. Computer solutions to engineering problems are required in EE 3200 and subsequent courses.

ELECTIVES

The electrical engineering curriculum contains fifty-seven hours of electives in addition to thirty hours of specified humanities/social sciences/modern languages electives. The fifty-seven hours of electives must include a minimum of

1. three hours of freshman engineering electives (See below);
2. three hours of junior-level or senior-level course work in written or verbal communications of ideas. Choose either ENGL 3015 or 3020;
3. twelve hours of technical electives subject to School approval. Generally, the technical electives are junior or senior engineering (not EE), mathematics, or natural sciences courses. These electives must include one of the following thermodynamics options: (1) ME 3720, (2) ME 3322 and ME 3323, (3) PHYS 3141, or (4) a course or courses approved by the School of Electrical Engineering. A course in graphics is also strongly recommended;

4. eighteen hours of electrical engineering electives, subject to School approval;
5. three hours (minimum) of applied probability selected from (1) EE 3340, (2) ISYE 3027, (3) BIOL 3332, (4) MATH 3710, (5) MATH 3215, or (6) MATH 4215. EE 3340 will apply toward satisfying the EE elective course requirements; all other courses will apply toward satisfying the technical breadth requirement for the bachelor's degree in electrical engineering;
6. twenty-one hours of free electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

Freshman Engineering Elective

Any of the following courses are acceptable for credit as freshman engineering electives: EGR 1170, CERE 1010, CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

Humanities/Social Sciences/Modern Languages Electives

Three credit hours each of history and political science must be included. Additional humanities/social sciences/modern languages electives and their required distribution are given in "Information for Undergraduate Students," pp. 41-42. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Computer Engineering

Computer engineering is a discipline within electrical engineering that combines the study of computer systems with the traditional aspects of engineering. The increasing use of computers in all engineering disciplines has created a demand for professionals with computer hardware and software skills and with an understanding of the fundamentals of engineering.

In order to address the specialized needs of students interested in computer engineering, the School of Electrical Engineering offers the bachelor's degree in computer engineering. The objective of this degree is to produce graduate engineers at the baccalaureate level who are able to design, analyze, and use computer systems in an engineering environment. The program in computer engineering encompasses both areas of computer design and computer applications. Computer design emphasizes the structure of computers and requires expertise in computational theory, digital design, and computer architecture. Computer applications emphasizes the use of computers in engineering systems and requires computer interfacing techniques, both low-level and high-level programming techniques, mathematical algorithms, and a general knowledge of computer operating systems. Both areas require an in-depth understanding of computer software at the machine and systems level.

The program requires a total of 204 quarter hours for graduation, exactly the same number of hours required for the bachelor's degree in electrical engineering. Of these, ninety-one hours are devoted to engineering and technical subjects; fifty-six hours to mathematics, physics, and chemistry; thirty-six hours to the humanities and social sciences; and the rest distributed among free electives and miscellaneous other areas. Details are given in the curriculum description that follows.

Those undergraduate engineering students who wish to receive a degree in a field other than computer engineering but with an emphasis on computers may elect to pursue a certificate in computer engineering. To qualify for this certificate, a student must complete all requirements for an ABET-accredited bachelor's degree in an engineering discipline and, in addition, must successfully complete, with a grade of C or better, the following nine elective courses totaling thirty quarter hours: EE 1010, 3032-3-4, 4072 or 4074, 4075, 4080, ICS 2101, and MATH 2012. None of these courses may be specifically required by title and number for the bachelor's degree in the student's major field. Nonelectrical engineering students may substitute EE 3360 for one of the EE courses listed in the program.

Additional information about the programs may be obtained from the School's Student Handbook, available upon request or by calling the School at (404) 894-2900. Every student enrolled *must consult* this source of information concerning special rules and degree requirements.

Bachelor of Computer Engineering Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
ICS 1410-1 Programming Concepts, Standards and Methods I, II	.....	3-3-4	3-3-4
Freshman Engineering Elective	3-0-3	.....	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	X-X-3	.....	.....
TOTALS	X-X-19	15-6-17	15-6-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3709 Mathematics for System Engineering	.....	.....	3-0-3
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
EE 3200-50 Elements of Electrical Engineering	.....	3-0-3	3-0-3
EE 3400 Instrumentation Laboratory	.....	.....	1-3-2

EE 3360			
Digital Hardware	3-0-3	.....	.....
EE 3411			
Junior Electrical Engineering Laboratory I	0-3-1	.....	.....
ICS 2201			
Data Structures	.....	.....	3-3-4
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Elective	.....	.....	3-0-3
TOTALS	X-X-17	X-X-16	16-6-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 3012			
Applied Combinatorics	3-0-3	.....	.....
EE 3210			
Circuits and Systems	3-0-3	.....	.....
EE 3215			
Signals and Systems	.....	3-0-3	.....
EE 3260			
Engineering Electronics	3-0-3	.....	.....
EE 3340			
Random Signals and Noise	.....	.....	3-0-3
EE 3421			
Junior Electrical Engineering Laboratory II	.....	0-3-1	.....
EE 3350			
Fundamentals of Semiconductor Devices	.....	3-0-3	.....
EE 3300-10			
Electromagnetics I, II	3-0-3	3-0-3	.....
EE 4411			
Senior Electrical Engineering Laboratory I	.....	.....	0-3-1
EE 3032-3-4			
Computer Engineering I, II, III	3-0-3	3-3-4	3-0-3
ICS 3410			
Programming Languages	.....	.....	3-3-4
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Elective	.....	.....	3-0-3
TOTALS	18-0-18	15-6-17	15-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ICS 4430			
Introduction to Operating Systems	.....	3-0-3	.....
EE 4073			
Introduction to VLSI Design	3-3-4	.....	.....
EE 4074			
Local Computer Networks	.....	3-0-3	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Electives	10-0-10	7-0-7	12-0-12
TOTALS	16-3-17	16-0-16	15-0-15

SUBSTITUTIONS

ICS 2601-2 and 3602 may be substituted for EE 3032-3-4.

ELECTIVES

The computer engineering curriculum contains thirty-eight hours of electives in addition to thirty hours of specified humanities/social sciences/modern languages electives. The thirty-eight hours of electives must include a minimum of

1. three hours of freshman engineering electives. Any of the following courses are allowed: EGR 1170, CERE 1010, CHE 1110, CE 1503, EE 1011, ESM 1101, NE 1100, NS 1002, 1003, or TEX 1100;
2. three hours of junior-level or senior-level course work in Written or verbal communication of ideas, which may include one of the following English courses: ENGL 3015 or 3020;
3. ten hours of technical electives, subject to School approval. Generally, the technical electives are junior or senior engineering (not EE), mathematics, or natural science courses. These electives must include one of the following four thermodynamics options: (a) ME 3720; (b) ME 3322-3; (c) PHYS 3141, or (d) a course or courses approved by the School of Electrical Engineering. ESM 2201 and ESM 3201 are recommended for students planning to take

the EIT examinations. In addition, one course in graphics is strongly recommended;
4. seven hours of computer engineering, electrical engineering, or computer science electives, subject to School approval;
5. fifteen hours of free electives. Free electives may be taken at any time during a student's course of study. All of these hours may be satisfied using ROTC credits for ROTC students.

Humanities/Social Sciences/Modern Languages Electives

Three credit hours each of history and political science must be included. Additional humanities/social sciences/modern languages electives and their required distribution are given in "Information for Undergraduate Students," pp. 41-42. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Courses of Instruction

EE 1001. Introduction to Electrical Engineering
1-0-1. Enrollment limited to freshmen.
An introduction to electrical engineering, both at Georgia Tech and in industry. Lectures, discussion, and outside work provide insight to the exciting directions the profession is taking.

EE 1010. Computer Programming and Graphics
2-3-3.
Computer programming and graphics using a problem-solving approach. Programs are written in FORTRAN for the main campus computer and a CALCOMP PLOTTER.
Text: Ageloff and Mojena, *Applied FORTRAN 77 Featuring Structured Programming.*

EE 1011. Electrical Engineering Fundamentals
2-3-3.
Survey of the diverse areas within electrical engineering. Basic engineering concepts developed and applied quantitatively to representative engineering problems.

EE 1900-1-2-3. Special Problems
Credit to be arranged. Normally taken by freshmen.
Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 2900-1-2-3. Special Problems
Credit to be arranged. Normally taken by sophomores.
Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 3015. Mechanical Plant of Buildings
3-0-3. Prerequisite: EE 3200 or EE 3701.
Electrical power distribution systems for buildings and plants. Study of National Electrical Code. Lighting design considering sources, luminaires, and reflectances.
Text: McGuinness, Stein, Gay, and Fawcett, *Electrical Equipment for Buildings.*

EE 3032. Computer Engineering I
3-0-3. Prerequisites: EE 1010, 3360.
Microcomputer systems, microprocessor architecture and design. Assembly language programming, modular programming, I/O programming. Multiprocessor configurations.
Text: Liu and Gibson, *Microcomputer Systems: The 8086/8088 Family.*

EE 3033. Computer Engineering II
3-3-4. Prerequisite: EE 3032.
Register transfer level design of computing structures, including sequences for instruction fetch, arithmetic/logic unit operations, microoperations, and timing and control. Discussion of bus structures, interrupts, and input/output. Design projects based on CDL implementations.
Text: Tanenbawm, *Structured Computer Organization.*

EE 3034. Computer Engineering III
3-0-3. Prerequisite: EE 3032.
A study of computational algorithms for computers and their implementation via hardware and software. Topics include fixed point, BCD, and point operations, special functions, residue arithmetic, and multivalued logic.
Text: Cavanagh, *Digital Computer Arithmetic: Design and Implementation.*

EE 3036. Computational Methods for Simulation
3-0-3. Prerequisite: MATH 2309 or 3308.
A study of numerical algorithms for solving complex electrical engineering problems using digital computers. Theoretical approaches and practical algorithms are discussed.
Text: DeBoor and Conte, *Elementary Numerical Analysis.*

EE 3042. Electrical Measurements
3-3-4. Prerequisites: EE 3270, 3360, 3421.
A study of measurements of electrical quantities using electromechanical and electronic, analog, and digital methods, consideration of recording, indication and processing of measurement data.
Text: Cooper, *Electronic Instrumentation and Measurement Techniques.*

EE 3200. Elements of Electrical Engineering I
3-0-3. Prerequisites: PHYS 2122, MATH 2307.
Introduction to basic concepts of circuit elements, circuit models, and techniques for circuit analysis.
Text: Su, *Fundamentals of Circuits, Electronics, and Signal Analysis.*

EE 3210. Circuits and Systems I
3-0-3. Prerequisite: EE 3250, MATH 3308.
System analysis in the time and frequency domains. Convolution, Fourier series, and Fourier transforms with applications.
Text: Oppenheim and Wilskey, *Signals and Systems.*

EE 3215. Signals and Systems
3-0-3. Prerequisite: EE 3210.
   An introduction to the fundamentals of signal representation, system characterization, and signal processing with applications to communication, control, and instrumentation.
   Text: Oppenheim and Wilsky, *Signals and Systems*.

EE 3220. Circuits and Systems II
3-0-3. Prerequisite: EE 3210.
   Representation of continuous and discrete dynamic systems utilizing transform and state variable techniques. Properties of closed-loop systems. Stability analysis.
   Text: Dorf, *Modern Control Systems*.

EE 3250. Elements of Electrical Engineering II
3-0-3. Prerequisite: EE 3200. Corequisite: EE 3400.
   Development of concepts in modeling terminal characteristics of electronic devices and techniques for analyzing electronic circuits.
   Texts: Su, *Fundamentals of Circuits, Electronics, and Signal Analysis*.

EE 3260. Engineering Electronics
3-0-3. Prerequisite: EE 3250.
   Development of techniques necessary for the analysis of active linear electronic circuits.
   Text: Sedra and Smith, *Microelectronic Circuits*.

EE 3270. Nonlinear Devices and Circuits
3-0-3. Prerequisite: EE 3260.
   Presentation of concepts important in the analysis and design of systems utilizing linear and nonlinear devices and circuits.
   Text: Sedra and Smith, *Microelectronic Circuits*.

EE 3300. Electromagnetics I
3-0-3. Prerequisites: MATH 3308, PHYS 2122, and EE 3250.
   A study of Maxwell's equations. Electromagnetic theory of simple media. Electrostatics, magnetostatics, and electromagnetostatics.
   Text: Ramo, Whinnery and Van Duzer, *Fields and Waves in Communication Electronics*.

EE 3310. Electromagnetics II
3-0-3. Prerequisites: EE 3300, 3210.
   Electromagnetic energy and momentum. Virtual work and forces. Reflection and refraction of plane waves in dissipative media. Traveling waves and standing waves.
   Text: Ramo, Whinnery, and Van Duzer, *Fields and Waves in Communication Electronics*.

EE 3320. Electromagnetics III
3-0-3. Prerequisite: EE 3310.
   Transmission lines and waveguides. Wire and aperture antennas. Arrays. Quasistatics.
   Text: Ramo, Whinnery and Van Duzer, *Fields and Waves in Communication Electronics*.

EE 3330. Electromechanical Systems and Energy Conversion
3-0-3. Prerequisites: EE 3310, 3210.
   Fundamentals of electromechanical energy conversion, electromechanical devices and systems. Energy state function, force energy relationships, basic transducers, introduction to A.C. and D.C. machines.

Text: Brown, Hamilton III, *Electromechanical Energy Conversion*.

EE 3340. Random Signals and Noise
3-0-3. Prerequisite: EE 3215.
   Study of probability, random variables, and random processes for applications in electrical engineering.
   Text: Cooper and McGillem, *Probabilistic Methods of Signal Analysis*.

EE 3350. Fundamentals of Semiconductor Devices
3-0-3. Prerequisite: EE 3250
   For computer engineering degree candidates. An introduction to the crystal structure and band theory of semiconductors. Conduction processes, optical effects, and semiconductor junctions are also treated.

EE 3360. Digital Hardware
3-0-3. Corequisite: EE 3411.
   A study of gates, flip-flops, counters, registers, memory devices, and integrated circuits. Consideration of the architecture of computers and digital systems.
   Text: Greenfield, *Practical Digital Design Using ICs*.

EE 3400. Instrumentation Laboratory
1-3-2. Prerequisite: EE 3200. Corequisite: EE 3250 (for electrical engineering students) or EE 3701 (for nonelectrical engineering students).
   Introduction to instrumentation equipment and techniques. Basic laboratory techniques and practice. Operation of oscilloscopes and meters. Measurement of parameters of electrical engineering components and devices.

EE 3411. Junior Electrical Engineering Laboratory I
0-3-1. Corequisite: EE 3360.
   Exercises in combinational and sequential design and hardware implementation utilizing TTL gates, flip-flops, multiplexers, and counters.
   Text: Wallace, *Digital Hardware Laboratory Experiments*.

EE 3421. Junior Electrical Engineering Laboratory II
0-3-1. Prerequisite: EE 3400. Corequisite: EE 3270 (for electrical engineering students) or EE 3702 (for nonelectrical engineering students).
   Experiments in linear circuits and electronics with emphasis on the relationship between circuit models and their physical realization.

EE 3431. Junior Electrical Engineering Laboratory III
0-3-1. Prerequisites: EE 3270, 3400.
   Presentation of topics for experimentation in circuits and electronics which illustrate the operation and application of integrated circuits.
   Text: Connelly, *Experiments with Integrated Circuits and Systems*.

EE 3701. Electric Circuits
2-0-2. Prerequisites: MATH 2308, PHYS 2122.
   For nonelectrical engineering students. Study of electric circuit elements and of the steady-state and transient response of circuits to periodic and step inputs.
   Text: Fitzgerald et al., *Basic Electrical Engineering*.

EE 3702. Elementary Electronics
2-0-2. Prerequisite: EE 3701.
   For nonelectrical engineering students. An introduction to electronic and semiconductor devices and a study of

circuits containing such elements. Both linear and digital systems are considered.
   Text: Fitzgerald et al., *Basic Electrical Engineering*.

EE 3703. Electric Power Conversion
2-0-2. Prerequisite: EE 3701.
   For nonelectrical engineering students. A study of energy conversion principles and devices such as motors, generators, transformers, and rectifiers.
   Text: Fitzgerald et al., *Basic Electrical Engineering*.

EE 3900-1-2-3. Special Problems
Credit to be arranged. Normally taken by juniors.
   Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 4011. Analog Filter Design
3-0-3. Prerequisite: EE 3220.
   An introduction to the theory, design techniques, and applications of analog passive and active filters.
   Text: Johnson, *Introduction to Filter Theory*.

EE 4012. Electric Energy Conversion
3-3-4. Prerequisite: EE 3330.
   Principles of rotating A.C. and D.C. machines. Analysis techniques and application studies of individual and interconnected devices. Coordinated laboratory exercises.
   Text: Matsch, *Electromagnetic and Electromechanical Machines*.

EE 4015. Principles of Feedback Control
3-3-4. Prerequisite: EE 3220.
   A study of automatic control systems. Basic control principles, system modeling, and analysis techniques. Coordinated laboratory exercises.
   Text: D'Azzo and Houpis, *Linear Control System Analysis and Design*.

EE 4017. Pulse Circuits
3-0-3. Prerequisite: EE 3270.
   Systems analysis/design for processing analog and digital data, generation and synchronization of sweeps, switching considerations of MOSFET multivibrators, active-element memories, D.-A. and A.-D. converters.
   Text: Millman, *Microelectronics*.

EE 4019. Power System Analysis
3-0-3. Prerequisite: EE 3330 or consent of the School.
   A study of power systems, power system components, and techniques of analysis.
   Text: Elgerd, *Electric Energy Systems Theory*.

EE 4021. Electromagnetic Properties of Solids
3-3-4. Prerequisite: EE 4350.
   Properties of dielectric and magnetic materials, including piezoelectricity, superconductivity, magnetic domain dynamics, and ferromagnetic resonance. Applications as transducers, memories, logic elements, and microwave devices.

EE 4022. Industrial Electronics
3-3-4. Prerequisite: EE 4039.
   The understanding, analysis, and design of analog and microprocessor-based continuous and discrete-state process control systems, including input signal conditioning and final control elements.

Text: Johnson, *Process Control Instrumentation Technology* and Johnson, *Microprocessor-based Process Control*.

EE 4023. Integrated Circuits and Systems
3-0-3. Prerequisite: EE 3270.
   A study of integrated circuit technology available today. The merits and drawbacks to electronic applications offered by circuit configurations available in digital and linear ICs.
   Text: Millman, *Microelectronics*.

EE 4024. Speech Analysis, Synthesis, and Compression
3-0-3. Prerequisite: EE 3210 or consent of the School.
   Modern speech analysis and synthesis techniques as applied to the communication problem of speech synthesis. Classical phonology, vocoders, vocal track analogs, spectral analysis of speech.
   Text: Flanagan, *Theory of Speech Analysis, Synthesis and Perception*.

EE 4025. Information Theory
3-0-3. Prerequisite: EE 3340 or MATH 4215 or equivalent.
   Definitions and applications of the measure of information, redundancy, channel, channel capacity and mutual information, and Shannon's coding theorems are presented with emphasis on communication problems.
   Text: Hamming, *Coding and Information Theory*.

EE 4026. Audio Engineering
3-0-3. Prerequisites: EE 3270, 3310.
   An introduction to the application of the tools of electrical engineering to the detection, measurement, processing, recording, and reproduction of audio frequency signals. Basic principles of sound. Microphones. Loudspeakers. Power amplifiers. Disk phonograph systems. Magnetic tape systems. Broadcast audio. Audio signal processing. Acoustical instrumentation.

EE 4027. Computer Graphic Design
3-0-3. Prerequisites: EE 1010 or equivalent and junior standing.
   Principles of computer-aided design (CAD), with emphasis on interactive graphics. Engineering applications and introduction to hardware and programming for interactive computing.
   Text: Giloi, *Interactive Computer Graphics*.

EE 4028. Communication Engineering I
3-3-4. Prerequisites: EE 3210, 3270.
   Circuit design for communication systems operating below one gigahertz. Impedance matching, introduction to random noise, small signal and power amplifiers, primarily for analog system applications.

EE 4030. Communication Engineering II
3-3-4. Prerequisites: EE 3210, 3270.
   Theory and practice in the design of radio and television receivers. Also a study of signal propagation, radio frequency interference, frequency allocation, and fundamental antennas.

EE 4031. Microwave Devices and Circuits
3-0-3. Prerequisite: EE 3320.
   To acquaint the student with specific properties of microwave transmission lines and waveguides, with the

design of passive microwave components, and with the characteristics of various microwave sources.

Text: Gandhi, *Microwave Engineering and Applications.*

EE 4033. Network Synthesis
3-0-3. Prerequisite: EE 3210.

A study of one- and two-port networks from the point of view of modern network synthesis.

Text: Temes and Lapatra, *Circuit Synthesis and Design.*

EE 4035. High Frequency Amplifier Design
3-0-3. Prerequisites: EE 3270, 3320.

An introduction to the techniques used in the analysis and design of high frequency amplifiers, with emphasis placed on design.

Text: Carson, *High Frequency Amplifiers.*

EE 4037. Antennas
3-3-4. Prerequisite: EE 3320.

Introduction to linear antennas, linear arrays, and aperture antennas. Far field pattern calculation and measurement are presented. Students design and construct antennas in associated laboratory.

Text: Balanis, *Antenna Theory, Analysis, and Design.*

EE 4039. Electrical Sensors and Transducers
3-0-3. Prerequisites: EE 3360, 3210, and 3270 or consent of the School.

The understanding, analysis, and design of transducer subsystems, including associated signal-conditioning circuitry, integrated timing circuits, and polyphase free and controlled rectifiers.

Text: Johnson, *Process Control Instrumentation Technology.*

EE 4041. Illumination Engineering
3-0-3. Prerequisites: PHYS 2123, EE 3310.

An introduction to interior and exterior lighting design. Basic topics considered are light, sight, color, photometry, illumination, luminaires, and sources.

EE 4043. Linear Graph Theory
3-0-3. Prerequisite: EE 3210.

Comprehensive and unified study of oriented and non-oriented graphs for use in network topology, analysis and synthesis, signal flow theory, and communication networks.

EE 4045. Power System Protection
3-0-3. Prerequisite: EE 4019.

An introduction to fundamental concepts in the protection of electric power system apparatus.

Text: Blackburn, *Applied Protective Relaying.*

EE 4046. Power System Engineering
3-0-3. Prerequisite: EE 4019.

Modeling of power system elements and components, elements of steady state operation and power system protection.

Text: Elgerd, *Electric Energy Systems Theory.*

EE 4047. Power Electronics
3-0-3. Prerequisite: EE 3270.

An introduction to power semiconductor devices and to the electronic circuits incorporating these devices that can be used in the amplification, generation, and control of electrical energy.

EE 4050. Optical Engineering
3-0-3. Prerequisite: EE 3320 or consent of the School.

Introduction to optics and optical systems as applied modern engineering problems. Image formation, holography, optical data processing, optical memories, specification of optical systems, fiber optics.

Text: Meyer-Arendt, *Classical and Modern Optics.*

EE 4051. Fiber Optics
3-0-3. Prerequisite: EE 3320.

An introduction to optical fibers as applied to communication systems. Topics include field theory of step index fibers, dispersion, coupling, sources, detectors, and elementary system design.

Text: Gerd Keiser, *Optical Fiber Communications.*

EE 4055. Semiconductor Device Electronics
3-0-3. Prerequisite: EE 4350 or consent of the School.

An introduction to the basic physical principles involved in the analysis of semiconductor devices important to microelectronics and instrumentation.

Text: E. S. Yang, *Fundamentals of Semiconductor Devices.*

EE 4056. Integrated Circuit Fabrication
3-0-3. Prerequisite: EE 4055 or 4023.

A basic study of the fabrication processes required to create silicon integrated circuits. Emphasis is placed on wafer processing techniques and device realization.

EE 4057. Integrated Circuit Device Electronics
3-0-3. Prerequisite: EE 4055 or equivalent.

A detailed examination of the active devices important in high-density integrated circuits. Emphasis is placed on advanced device physics and design aspects.

EE 4061. Communication Systems
3-0-3. Prerequisites: EE 3340 or equivalent, EE 3215.

Modern binary and M-ary digital signaling techniques. Noise processes and their effect on binary signaling. Matched filter receivers.

Text: Leon W. Couch, *Digital and Analog Communication Systems.*

EE 4062. Communication Systems Laboratory
0-3-1. Prerequisites: EE 3215 and 3400 or equivalent. Corequisite: EE 4061.

Experiments in signal processing and communication systems.

EE 4063. Communication Systems II
3-0-3. Prerequisite: EE 4061

Performance analysis of analog and M-ary digital communications in noise. Satellite communications link analysis. AM, FM TV stereo systems. Spread-spectrum techniques.

Text: Couch, *Digital and Analog Communication Systems*

EE 4072. Automatic Measurements
2-3-3. Prerequisite: EE senior standing.

An introduction to measurements carried out by instruments and a programmable controller via the IEEE-488 general purpose interface bus.

EE 4073. Introduction to VLSI Design
3-3-4. Prerequisite: EE 3360.

An introduction to the basic concepts of structured digital design and Very Large Scale Integration (VLSI) technology. Emphasis is placed on fundamental logic layouts for NMOS and CMOS integrated circuits.

Text: Mead and Conway, *Introduction to VLSI Design.*

EE 4074. Local Computer Networks
3-0-3. Prerequisites: EE 3032 and a course in probability.

An introduction to the design and performance analysis of local computer communication networks, emphasizing analysis of representative multi-access procedures. Polling networks, random access networks, and ring networks are considered in detail.

EE 4075. Microcomputer-based Design
3-3-4. Prerequisites: EE 3032 and EE 3360 or equivalent.

Development of the ability to define and design "smart" devices and instruments using a microcontroller (i.e., a single-chip microcomputer) is emphasized.

Text: Peatman, *Design with Microcontrollers.*

EE 4078. Digital Signal Processing
3-0-3. Prerequisite: EE 3215.

An introduction to the theory and application of processing discrete data. Special attention will be paid to the design and implementation of both FIR and IIR digital filters.

Text: Oppenheim and Schafer, *Digital Signal Processing.*

EE 4079. Introduction to Automaton Theory
3-0-3. Normally taken by seniors.

A study of the properties of linear sequential systems in relation to their applications in various digital tasks.

EE 4080. Introduction to Sequential Systems.
3-0-3. Prerequisite: EE 3360 or equivalent.

A study of procedures for synthesis of synchronous and asynchronous sequential systems.

Text: Hill and Peterson, *Switching Theory and Logical Design.*

EE 4081. Introduction to Bioelectronics
3-0-3. Prerequisite: EE 3270 or consent of the School.

An introduction to the study of the electrical phenomena of biological systems. The measurement and control of biological systems.

EE 4082. Linear System Theory
3-0-3. Prerequisite: EE 3220.

Linear system theory with emphasis on transform and state-variable methods. Applications to both continuous and discrete systems.

Text: Brogan, *Modern Control Theory.*

EE 4083. Computer Simulation of Systems
3-3-4. Prerequisite: EE 3220.

Simulation methods by analog, digital, and hybrid computers. Digital simulation languages. State variable approach to system simulation. Simulation of complicated systems. Examples and class problems.

EE 4084. Transistor Circuit Analysis
3-0-3. Prerequisite: EE 3270. Corequisite: EE 4085.

Analysis and design of linear electronic circuits. Single stage amplifiers, multistage amplifiers, tuned amplifiers with emphasis on design techniques.

Text: Sedra and Smith, *Microelectronic Circuits.*

EE 4085. Electronic Design Laboratory
0-3-1. Corequisite: EE 4084.

Practical design problems that emphasize creativity and imagination are posed, and their solutions are individually implemented in the laboratory.

EE 4086. Operational Amplifier Design
3-3-4. Prerequisite: EE 3270.

Theory and applications of operational amplifiers as they are currently utilized in today's electronic systems to produce both linear and nonlinear functional operations.

Text: Wait, *Introduction to Operational Amplifier Theory and Applications.*

EE 4087. Biomedical Instrumentation
3-3-4. Prerequisite: EE 3260 or 3702.

Instrumentation used in the hospital and clinic from a systems viewpoint. Includes a review of pertinent physiological and electrophysiological concepts.

EE 4090. EE Senior Seminar
1-0-1. Prerequisites: EE junior standing.

Bridge between an undergraduate electrical engineering education and a postgraduate career. Talk followed by a question-and-answer period with various authorities.

EE 4095. Electrical Transients in Power Systems
3-0-3. Prerequisite: EE 3210, 4019 or consent of the School.

Analysis of transient conditions in power systems. System parameters. Types of transients. Protective devices and techniques.

EE 4350. Materials Science
3-0-3. Prerequisites: EE 3310, 3270.

A study of the physical, electrical, and optical properties of metals, semiconductors, dielectrics, and magnetic materials with emphasis on microscopic as well as macroscopic behavior.

Text: Omar, *Elementary Solid State Physics.*

EE 4411. Senior Electrical Engineering Laboratory I
0-3-1. Prerequisite: EE 3400. Corequisite: EE 3320.

The use, operation, and limitations of standard electromagnetic field measurement and signal generating equipment.

EE 4421. Senior Electrical Engineering Laboratory II
0-3-1. Prerequisite: EE 3400. Corequisite: EE 3330 (for electrical engineering students) or EE 3703 (for non-electrical engineering students).

Experimental studies of electromagnetic and electromechanical systems.

EE 4430. Project Laboratory
0-3-1. Prerequisite: EE 3400. Normally taken by seniors.

Individual experimental investigations and projects tailored to student interests. Projects are selected in consultation with student's faculty adviser.

EE 4751. Laser Theory and Applications
3-0-3. Prerequisite: PHYS 2123.

Principles of laser operations. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both EE and non-EE majors. Also taught as PHYS 3751.

Text: O'Shea, *Introduction to Lasers and Their Applications.*

EE 4780. Energy Conversion Engineering
3-0-3. Prerequisite: thermodynamics.

Principles of advanced energy conversion for electric power. Operation and engineering considerations. Also taught as ME 4780 and NE 4780.

Text: Angrist, *Direct Energy Conversion*.

EE 4801-2-3-4-5. Special Topics
3-0-3 each. Normally taken by seniors.

New developments in electrical engineering are presented as demand or interest warrants.

EE 4900-1-2-3. Special Problems
Credit to be arranged. Normally taken by seniors.

Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 6050. Random Processes I
3-0-3. Prerequisite: graduate standing.

An introduction to the concepts of probability theory and random variables with applications to electrical engineering problems.

EE 6051. Random Processes II
3-0-3. Prerequisite: EE 6050 or equivalent.

An introduction to the theory of stochastic processes. Filtering and harmonic analysis. Energy properties. Wiener, Poisson, Gaussian, Markov processes. Engineering applications are emphasized.

EE 6057. Telecommunications I
3-0-3. Prerequisites: EE 6050, 6070, or equivalent.

Basic binary and M-ary digital signaling techniques with emphasis on the effects of noise. Performance analysis and comparisons of alternative systems.

EE 6058. Telecommunications II
3-0-3. Prerequisite: EE 6057.

Extension of EE 6057. Intersymbol interference, partial response systems, synchronization techniques, and other signaling techniques.

EE 6063. Methods in Pattern Recognition
3-0-3. Prerequisite: EE 6050.

Introduction to pattern recognition. Several approaches to pattern classification, feature extraction, and training are considered, including the use of linear discriminant functions, clustering, gradient methods, and syntactic pattern recognition. Several examples of pattern recognition systems are also included.

EE 6070. Fourier Techniques and Signal Analysis
3-0-3. Prerequisite: graduate standing or consent of the School.

Fourier Transform applications to the analysis of signals in communications, controls, electromagnetics, optics, and signal processing.

EE 6072. Fourier Optics and Holography
3-0-3. Prerequisite: EE 6070 or consent of the School.

Principles of diffraction, lenses, coherent and incoherent imaging, optical information processing, and holography presented in a linear systems framework.

EE 6073. Optical Signal Processing
3-0-3. Prerequisite: EE 6072 or consent of the School.

An introduction to the principal concepts, methods, and technology of coherent, incoherent, acousto-optic, numerical, and logic-based optical signal processing.

EE 6081. Information Theory
3-0-3. Prerequisite: EE 6050.

Introduction to information theory. The concepts of information, information rate, and channel capacity are developed and applied to communication theory problems.

EE 6082. Coding
3-0-3. Prerequisite: graduate standing.

Coding techniques for efficient, reliable communication are introduced. Techniques studied include parity-check, maximal-length, Hamming, BCH and convolutional codes, Viterbi decoding and coding for burst-noise channels.

EE 6092. Computer Communication Systems
3-0-3. Prerequisite: graduate standing.

A study of quantitative design techniques for computer communication networks. Capacity assignment, concentrator and buffer design, and choice of network geometry are among topics covered.

EE 6100. Linear Networks and Systems
3-0-3. Prerequisite: graduate standing or consent of the School.

Introduction to a rigorous treatment of linear systems theory. Topics include theory of vector spaces, linear transformations, state variables, linear dynamical systems, controllability, and observability.

EE 6101. Time Varying and Nonlinear Systems
3-0-3. Prerequisite: EE 6100.

Analysis and design of engineering systems with time varying and/or nonlinear characteristics. Systems representation and properties of the presentation. Linearization techniques. Stability analysis using Liapunov and Popov's theories.

EE 6111. Feedback Control Systems I
3-0-3. Prerequisite: EE 6100.

Optimal control approach to control system design. Formulation of optimal control problems using state-space programming, calculus of variations and maximum principles.

EE 6112. Feedback Control Systems II
3-0-3. Prerequisite: EE 6050 and either 6111 or 6131.

Design techniques for stochastic dynamical systems. Analysis of stochastic systems, state estimation, stochastic control, and adaptive control.

EE 6113. Feedback Control Systems III
3-0-3. Prerequisite: EE 6100.

Application of discrete time control to continuous systems. Time and frequency domain analysis of sampled data systems.

EE 6114. Adaptive Processors and Controllers
3-0-3. Prerequisites: EE 6100 and 6050 or 3340.

This course provides the concepts and fundamental mathematical theory of adaptation by performance feedback. Self-optimization algorithms and convergence aspects are considered in detail. Various applications to signal processing and control are discussed.

EE 6131. Optimum Linear Filters
3-0-3. Prerequisites: EE 6050, 6100 or consent of the School.

Estimation theory, both classical and modern approaches. Applications in communication and control. System identification techniques.

EE 6152. Computer Simulation
3-0-3. Prerequisites: graduate standing or consent of the School and elementary programming ability.

A study of computational methods for use in the digital simulation of deterministic systems. Several simulation projects are a part of the course.

EE 6154. Computer Hardware and Software for Manufacturing
3-0-3. Prerequisites: graduate standing and consent of the School.

This course provides an overview of the basic information processing services required to support manufacturing systems and processors. It is designed for the Computer Integrated Manufacturing Systems Program.

EE 6155. Computers in Manufacturing Laboratory
0-3-1. Prerequisite: graduate standing.

Introductory laboratory covering robot simulation, digital and analog I/O, and asynchronous communication.

EE 6161. Digital Systems Engineering I
3-0-3. Prerequisites: EE 3033, 4075, or equivalent.

A study of the basic concepts of computing structures and their impact on performance. Data types, addressing modes, fixed and floating point instruction timing, cache memory operation, error detection and correction, memory mapping, virtual memory, and parallel processing.

EE 6162. Digital Systems Engineering II
3-0-3. Prerequisites: EE 3033, 4075, or equivalent.

Concepts of microprogramming. Comparison of hardwired control and microprogrammed control. Design of a hypothetical microprogrammed computer. Design using bit slice technology, FPLAs, PALs, ROMs, and sequencers.

EE 6163. Digital Systems Engineering III
3-0-3. Prerequisite: EE 4075 or equivalent.

A study of information structures. Structures include stacks, deques, queues, circular lists, linked lists, doubly linked lists, trees, and collection of memory arrays, and orthogonal lists. Dynamic allocation is also treated.

EE 6170. Advanced Microcomputer-based Design
2-3-3. Prerequisite: EE 4075 or equivalent.

The study of software development for instrument design applications. High-level language and assembly language are applied in a real-time operating system environment.

EE 6201. Automata Theory I
3-0-3. Prerequisite: graduate standing (not recommended if student has already received credit for EE 4080).

An introduction to broad classes of digital systems including computer components as special cases. A detailed study is made of steps leading to optimum design.

EE 6202. Automata Theory II
3-0-3. Prerequisite: EE 6201 or 4080.

A continuation of digital system study, including fault detection and decomposition of systems. Reliability, memory span, and quadded logic are also examined.

EE 6203. Automata Theory III
3-0-3. Prerequisite: graduate standing or consent of the School.

An introduction to finite automata through study of sequential circuits. Concepts in modern algebra are developed for direct application to sequential circuits.

EE 6251. Applied Electromagnetics
3-0-3. Prerequisite: graduate standing or consent of the School.

Advanced electromagnetic theory. Particular and complementary solutions of the wave equation for both discrete and continuous cases. Analysis, synthesis, and boundary value problems.

EE 6252. Microwaves
3-0-3. Prerequisite: EE 6251.

Field analysis of guided waves. Equivalent-circuit theory of microwave systems. Broadband impedance matching. Passive microwave devices. Microwave cavities. Periodic structures and filters.

EE 6253. Antennas
3-0-3. Prerequisite: EE 6251; EE 4037 recommended.

Classical antenna theory. Antenna array analysis and synthesis. Electromagnetic characterization and design of several antenna types, such as wire, aperture, broadband, parasitic, helical, spiral, microstrip, and loop antennas. Introduction to antenna measurements.

EE 6254. Antenna Measurements
3-0-3. Prerequisite: EE 4037 or 6253 or consent of the School.

Electromagnetic parameters of antennas. Far field, near field, and compact range antenna measurements. Laboratory demonstrations are included.

EE 6301. Electro-optics
3-0-3. Prerequisite: graduate standing.

Introduction to electro-optics with emphasis on lasers and modern optics. Topics include Gaussian beams, laser theory and laser types, mode-locking, Q-switching, harmonic generation, parametric oscillation, and light modulation. Applications discussed include high-power laser systems and optical communications.

EE 6340. Integrated Optics
3-0-3. Prerequisite: graduate standing.

Theory and design of guided wave optical devices and integrated guided wave optical systems including fiber optics.

EE 6341. Fiber Optics
3-0-3. Prerequisite: graduate standing.

Field theory of optical fibers with emphasis on fiber-based devices. Topics include pulse propagation, measurement techniques, sensors, and nonlinear effects.

EE 6345. Optical Modulation
3-0-3. Prerequisite: graduate standing.

Birefringence; grating diffraction, electro-optic, photorefractive, and acousto-optic temporal and spatial modulation.

EE 6361. Integrated Circuits
3-0-3. Prerequisite: graduate standing.

Design, fabrication, and application considerations of monolithic linear ICs. Analysis of unconventional circuitry

contained in typical integrated circuits. Applications of available linear ICs.

EE 6362. Switched Capacitor Filters
3-0-3. Prerequisite: graduate standing or consent of the School.

A study of the application of MOS integrated circuit technology and analog sampled data theory for the realization of active filters.

EE 6363. Analog MOS Circuit Design
3-0-3. Prerequisite: graduate standing or consent of the School.

A study of the analysis and design of operational amplifiers, analog switches, digital-to-analog and analog-to-digital converters using modern MOS FET technology.

EE 6380. Frequency Synthesizers
3-0-3. Prerequisite: graduate standing.

The study of generating any arbitrary frequency from a given frequency standard. Digital and analog phase locked loops, frequency mixers, spurious signals, and phase noise are considered.

EE 6381. Low-noise Electronic Design
3-3-4. Prerequisite: graduate standing or consent of the School.

Sources of noise in electronic instrumentation design and employment of design techniques to reduce the effects of noise.

EE 6413. Digital Filters
3-0-3. Prerequisite: EE 4078 or equivalent.

Comprehensive treatment of the design, implementation, and application of digital signal processing algorithms. Sampling and A/D conversion, properties of discrete linear systems, digital filter design, implementation of digital filters, and fast algorithms for discrete Fourier analysis.

EE 6414. Advanced Digital Signal Processing
3-0-3. Prerequisite: EE 4078 and 6050 or equivalent.

A selection of advanced topics in digital signal processing. Topics include auto-regressive modeling, adaptive filtering, and power spectrum estimation.

EE 6415. Digital Processing of Speech Signals
3-0-3. Prerequisite: EE 4078 or 6413 or consent of the School.

A detailed treatment of the theory and application of digital speech processing. Provides fundamental knowledge about speech signals and speech processing methods and about how digital techniques are applied in speech transmission, speech synthesis, speech recognition, and speaker verification.

EE 6416. Multidimensional Digital Signal Processing
3-0-3. Prerequisite: EE 6413.

An introduction to the analysis and manipulation of signals of more than one independent variable, such as images and arrays of sensors. Topics covered include multidimensional digital filtering and multidimensional spectrum analysis.

EE 6417. Multidimensional Architectures for Digital Signal Processing
3-0-3. Prerequisite: EE 6413.

An introduction to the use of graph-theoretic, matrix, and statistical techniques to the implementation of digital

signal processing algorithms by multiprocessor computers. Topics covered include matrix representations for flow graphs, finite word length effects, and synchronous and asynchronous implementations.

EE 6421. Advanced Network Theory
3-0-3. Prerequisite: graduate standing or consent of the School.

An introduction to applied combinatorics, including combinations, permutations, recursion, partition, generating functions, inclusion and exclusion, rook polynomials, and Polya's theorem.

EE 6431. Electroacoustics
3-0-3. Prerequisite: graduate standing or consent of the School.

The practical application of electrical circuit theory to the solution of acoustical problems. Terminology. Basic solutions to the wave equation. Mechanical and acoustical circuits. Transducers. Radiation impedances. Acoustical elements. Direct radiator loudspeakers. Acoustics of enclosures. Loudspeaker system synthesis. Horn loudspeakers.

EE 6451. Electrical Properties of Materials
3-0-3. Prerequisite: graduate standing or consent of the School.

Basis of quantum mechanical formulism and modeling to serve as an introduction to the modern study of electrical properties of materials.

EE 6452. Magnetic and Dielectric Properties of Materials
3-0-3. Prerequisite: EE 6451 or consent of the School.

Dielectrics, piezo- and ferroelectrics and their application to electromechanical devices. Quantum basis of magnetism. Magnetic interactions, domains, resonance, and devices.

EE 6453. Solid-state Electronic Devices
3-0-3. Prerequisite: graduate standing or consent of the School.

Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.

EE 6454. Microstructure Fabrication Techniques
3-0-3. Prerequisite: EE 6361.

An examination of the physics, chemistry, and integrated circuit engineering techniques required to fabricate device structures with dimensions in the micron region.

EE 6461. Modern Magnetic Materials and Devices
3-0-3. Prerequisite: EE 6452 or consent of the School.

Basic operation and design of magnetic memories and microwave devices. Crystal structure, chemical composition. Properties of ferrites, garnets, and orthoferrites.

EE 6500. Introduction to Management and Control of Energy Systems
3-0-3. Prerequisite: EE 6100 or consent of the School.

Fundamentals of static as well as dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems.

EE 6501. Planning of Power Systems
3-0-3. Prerequisite: EE 4019, 6502, or consent of the School.

An introduction to planning procedures for large-scale technical operations. Technical and economic constraints on planning. Techniques for formulation of rational planning problems.

EE 6502. Control and Operation of Interconnected Power Systems
3-0-3. Prerequisite: EE 4019, 6100, or consent of the School.

Power flow analysis techniques. Modem control of power systems with emphasis on security, economic and environmental issues.

EE 6503. Evaluation of Power System Reliability
3-0-3. Prerequisite: EE 4019.

Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis.

EE 6511. Transmission Lines
3-3-4. Prerequisite: graduate standing.

A study of electric power transmission line parameters, models and techniques for analysis of steady state and transient conditions. A.C., D.C., HV, and underground transmission.

EE 6520. Real-time Control of Power Systems
3-0-3. Prerequisite: EE 4019, 6100, or consent of the School.

Real-time control functions in power systems. Energy control centers. Hierarchical, automatic generation, reactive power, and emergency controls. Security constraint economic operation.

EE 6521. Power System Stability
3-0-3. Prerequisites: EE 4019, 6100.

Methods of stability analysis of interconnected power systems. System modeling, analysis techniques for determination of static and dynamic stability.

EE 6530. Power Semiconductor Devices
3-0-3. Prerequisite: graduate standing or consent of the School.

The study of the physical considerations involved in the use of heavy-current semiconductor devices.

EE 6531. Solid-state Power Conversion
3-0-3. Prerequisite: graduate standing or consent of the School.

The study of the physical and electrical considerations involved in the analysis and design of solid-state inverters and converters.

EE 6550. Multivariable System Theory
3-0-3. Prerequisite: EE 6100.

Structural properties, controllability, observability, canonical forms. Applications to pole-shifting, decoupling, system realization and identification. Introduction to multidimensional systems.

EE 6773. Computer Control of Real-time Systems
3-3-4. Prerequisite: consent of the School. For non-electrical engineering students and for electrical engineering students whose major program area is not computers or digital systems.

A study of concepts common to all computer-controlled real-time systems. Subjects include evolution of

time sets, vectored interrupts, and statistical alarm conditions. Also taught as CE 6773, ME 6773, and NE 6773.

EE 6790. Computer Integrated Manufacturing Systems I
3-0-3. Prerequisite: graduate standing.

A broad overview of the functions, processes, and disciplines of computer Integrated manufacturing.

EE 6791. Computer Integrated Manufacturing Systems II
3-0-3. Prerequisite: EE 6790.

A in-depth study of current issues, emerging technologies, and future developments in computer integrated manufacturing.

EE 6792. Computer Integrated Manufacturing Systems Seminar
1-0-1. Prerequisite: graduate standing.

Guest speakers on a broad range of CIMS related topics; research, applications, and technology.

EE 6965. Power System Relaying
3-3-4. Prerequisite: EE 4019 or consent of the School.

Principles and techniques of electric power system protection. Application of relaying techniques for system stabilization, protection of high-voltage transmission system and substations. Coordinated field trips and demonstrations.

EE 6976. Advanced Electrical Transients
3-0-3. Prerequisite: graduate standing or consent of the School.

Development and application of those aspects of complex variable and transform theory which are helpful in the study of transients and which are particularly useful to electrical engineers in general.

EE 7000. Master's Thesis

EE 7051-2-3. Advanced Communication Theory
3-0-3. Prerequisite: consent of School.

Latest developments in communications are treated in lecture and seminar. Emphasis on current literature and open research areas.

EE 7101. Advanced Feedback Control Theory
3-0-3. Prerequisite: EE 6100.

Advanced techniques for analysis and design of automatic control systems.

EE 7251-2-3. Advanced Electromagnetic Theory
3-3-4 each. Prerequisite: consent of the School.

Topics of fundamental importance in electromagnetics. Advanced developments in the fields of antennas, propagation, and microwave theory and practice.

EE 7254. Antennas and Wave Propagation in Matter
3-0-3. Prerequisite: EE 6251 or consent of the School.

The analysis of antennas embedded in or near material bodies such as the earth or the ocean. Field equations and constitutive parameters in material regions; theoretical analyses of wire antennas; antennas as probes; wave propagation near a material interface; theory and construction of experimental scale models.

EE 8001-2-3. Seminar
1-0-1. Prerequisite: graduate standing and consent of the School.

EE 8140 through 8149. Special Topics
1-0-1 each.
Special topics of unusual current interest; introductory treatments of new developments in electrical engineering.

EE 8240 through 8249. Special Topics
2-0-2 each.

EE 8340 through 8349. Special Topics
3-0-3 each.

EE 8430 through 8439. Special Topics
4-0-4 each.

EE 8440 through 8449. Special Topics
5-0-5 each.

EE 8500-1-2-3. Special Problems
Credit to be arranged.
Problems meeting the special interests of the student. Approval to schedule must be obtained in advance of registration.

EE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

EE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

EE 9000. Doctoral Thesis

School of Industrial and Systems Engineering

School established in 1945, Department in 1924

Director—Michael E. Thomas, Robert N. Lehrer (emeritus); *Associate Director for Undergraduate Programs*—Nelson K. Rogers; *Associate Director for Graduate Programs*—William W. Hines; A. Russell Chandler III Chair—George L. Nemhauser; *Regents' Professors*—Harold E. Smalley, John A. White, Jr.; *Professors*—Leslie G. Callahan (emeritus), Stuart J. Deutsch, Paul T. Eaton (emeritus), Augustine O. Esogbue, David E. Fyffe, John J. Jarvis, Robert G. Jeroslow (adjunct), Cecil G. Johnson, Lynwood A. Johnson, Joseph L. Krol (emeritus), Alan L. Porter, H. Donald Ratliff, William B. Rouse, Richard L. Serfozo, C. M. Shetty, Rocker T. Staton (emeritus), Gerald J. Thuesen, Harrison M. Wadsworth; *Associate Professors*—Jerry Banks, John J. Bartholdi, Willard R. Fey, Robert D. Foley, Russell G. Heikes, Leon F. McGinnis, Justin A. Myr-

ick, Robert G. Parker, Loren K. Platzman, Frank E. Roper, Gunter P. Sharp, Craig A. Tovey, Gideon Weiss, Donovan B. Young; *Assistant Professors*—Faiz A. Al-Khayyal, Jane C. Ammons, Marc P. Goetschalckx, David Goldsman, T. Govindaraj, Steven T. Hackman, John M. Hammer, Donna C. Llewellyn, Christine M. Mitchell, James J. Swain, John J. VandeVate; *Instructors*— Howard E. Fagin, Thomas L. Sadosky, Ginner Weatherby; *Research Scientist II*— Richard L. Henneman; *Research Engineer I* —Edward H. Frazelle.

General Information
Industrial and systems engineering provides both a basic engineering foundation and a grounding in the interactions between technology and management. Students in the program are usually interested in obtaining a fundamental engineering background as the basis for professional specialization in activities associated with the field—operations research, management science, systems engineering, methods, organization, planning—or as preparation and foundation for other endeavors such as management, law, medicine, health systems, or other pursuits. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic, and social behavioral factors in industrial, service, social, and government organizations. The degree program offered is the Bachelor of Industrial Engineering (B.I.E.).

Bachelor of Industrial Engineering
The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences, and social sciences. Elective hours make the program flexible as does the senior-year design sequence, which permits a student to gain experience in design activities in manufacturing, service, health care, or government industries. The broad spectrum of required course work associated with the design

sequence qualifies the student to perform in operations and facilities, management information and controls, and systems engineering environments. Technical and free electives may be used to satisfy requirements for the Health Systems Option under the B.I.E. curriculum.

Options for Exceptional Students
An optional program is available to encourage students with superior abilities to participate in a range of unusual educational opportunities. Participation in these programs requires demonstrated scholastic excellence and prior arrangement with the student's adviser. The program includes the following options, individually or in combination.

Graduate-level courses in lieu of senior-year electives
Students with a cumulative grade point average of 3.3 or above may schedule up to nine credit hours of approved graduate-level courses. These credits, when approved by the student's adviser, may apply subsequently toward a graduate degree.

Accelerated study
Students with a 3.3 or above average during the three preceding quarters (including at least forty-five credits) may complete course requirements for any nonproject industrial and systems engineering course at their own pace by self study with counseling and guidance by the course instructor. Students may register for any number of courses but must satisfy instructor and course examination requirements. Class attendance is not required. Students must make arrangements with course instructors prior to the start of the quarter.

Individual project and research work
Students with a 3.0 or above average during the preceding three quarters (including at least forty-five credits) may schedule up to twelve credits of project work, research work, or both. The student will perform this work, which may substitute for senior-year electives, in collaboration with the faculty or advanced graduate students. Students with

less than a 3.0 average are limited to six credits of such project or research work.

Governor's intern program
ISYE seniors enrolled in the governor's intern program may receive six hours of design credit (4104-5) and six hours of ISYE elective credit for participation in the program.

Visiting Scholar/Practitioner Offerings
Occasionally, the School brings to campus selected individuals of unique accomplishment for course offerings built around their special areas of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

Program in Health Systems
Health systems is the field of study and practice aimed toward improving the delivery of health care services through the application of systems science and management engineering. Programs emphasize systematic planning, engineering design, and scientific management in respect to health care facilities, manpower, and methods.
The program in health systems is an academic aspect of the School of Industrial and Systems Engineering and is affiliated with the Medical College of Georgia. The program has education, research, and service components, and it engages in interdisciplinary and interinstitutional research, continuing education, and community outreach activities through the Health Systems Research Center.
Undergraduate preparation for this field is provided by a Health Systems Option under the B.I.E. degree curriculum. The undergraduate program prepares students for professional careers as health systems analysts and hospital management engineers.

Graduate Programs
The School of Industrial and Systems Engineering offers five master's degrees—the Master of Science in Industrial Engineering, the Master of Science in Operations Research, the Master of Science in Statistics,

the Master of Science in Health Systems, and the undesignated Master of Science—as well as the Doctor of Philosophy.

The M.S.I.E. program is available to students with an industrial engineering background and to other engineers who satisfy requirements covering the principal subject matter of the current Bachelor of Industrial Engineering curriculum. The M.S.O.R., M.S.S., and M.S.H.S. programs are available for students holding the B.S. in engineering, mathematics, or science. Requisites include work in probability, statistics, engineering economy, linear algebra, advanced calculus, and optimization, as well as selected application area work. The student may satisfy these requirements after enrollment; however, such course work may not apply toward fulfilling the degree requirements. The undesignated M.S. program is for those students who wish to work in the areas of systems analysis, man-machine systems engineering, or manufacturing systems. An undesignated M.S. program (thesis option) is also available for students who wish to pursue specific objectives not covered by the programs above.

The programs in industrial engineering, operations research, and health systems and the undesignated master's programs in man-machine systems engineering and manufacturing systems offer the option of either taking thirty-three credit hours of course work plus fifteen credit hours for research, culminating in a thesis, or taking forty-eight credit hours of course work. The program in statistics requires either thirty-three credit hours of course work plus seventeen credit hours for research, culminating in a thesis, or fifty credit hours of course work. Under the undesignated master's degree, the program in systems analysis permits only the thesis option.

The doctoral program is intended for highly gifted individuals for whom past accomplishments and evaluation indicate a high potential for successful completion of the program requirements and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a twelve-month basis. Students may begin graduate programs in any quarter.

Financial aid is available in the form of traineeships, fellowships, sponsored externships, and research and teaching assistantships.

Multidisciplinary Programs

Program in Statistics

The School of Industrial and Systems Engineering in the College of Engineering, the School of Mathematics in the College of Sciences and Liberal Studies, and the College of Management offer graduate work leading to the Master of Science in Statistics. The nature of this cooperative program emphasizes statistics as a science necessary in a technological environment such as that at Georgia Tech. Within this program, students can concentrate their studies on a specific area of application such as engineering, quality control, or management. Although this program can lead to further work toward a doctorate in statistics, it will primarily provide the background requisite for a professional career in statistics.

Career fields for graduates of this program may be found in virtually all areas of research, industry, and government. The program is designed to provide the graduate with competence to organize the collection, analysis, and interpretation of data reinforced by a sound understanding of statistical principles. Students will work with faculty actively engaged in research and prepared to teach the latest developments in statistics. By following either a thesis or nonthesis program, the student may complete the degree program in fifteen months. Students holding or anticipating an undergraduate degree from an accredited college or university in engineering, mathematics, science, or some other field that indicates a likelihood of successful completion of the program are encouraged to apply.

The program is administered by a committee appointed by the three schools. Currently the members of the committee are Harrison M. Wadsworth, Jr., Industrial and Systems Engineering, chair; M. Carl Spruill, Mathe-

matics; and David Nachman, Management. Interested students may obtain information regarding the program from any of these persons or from the associated schools.

The B.I.E. Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design	2-3-3	.....	.....
ICS 1700 Digital Computer Organizational Programming	.....	3-0-3	.....
and			
ICS 2101 Computer Programming	.....	.....	3-3-4
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
Physical Education (requirements, p. 253)	X-X-3	.....	.....
Humanities Elective	.....	.....	3-0-3
TOTALS	X-X-19	X-X-16	X-X-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
ECON 2000-1 Principles of Economics I, II	3-0-3	3-0-3	.....
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	.....
ESM 2201 Statics	.....	.....	3-0-3
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3709 Math for Systems Engineering	.....	.....	3-0-3
ISYE 3025 Engineering Economy	.....	.....	3-0-3
ISYE 3027 Applications of Probability	.....	.....	3-0-3
PSY 3303 General Psychology I	.....	.....	3-0-3
Social Sciences Electives	3-0-3	3-0-3	3-0-3
TOTALS	18-3-19	18-3-19	18-0-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3201 Dynamics I	3-0-3	.....	.....
ESM 3301 Mechanics of Deformable Bodies	.....	5-0-5	.....
ME 3720 Thermodynamics	.....	.....	4-0-4
EE 3701 Electrical Circuits	2-0-2	.....	.....
ISYE 3028-9 Engineering Statistics I, II	3-0-3	3-0-3	.....
ISYE 3105 Organizational Structures	3-0-3	.....	.....
ISYE 3010 Man-Machine Systems	.....	3-0-3	.....
ISYE 3215 Design and Measurement of Work Methods	.....	.....	3-0-3
ISYE 3231 Deterministic Operations Research	3-0-3	.....	.....
ISYE 3232 Probabilistic Operations Research	.....	3-0-3	.....
ISYE 3233 Advanced Operations Research	.....	.....	3-0-3
ISYE 4044 Simulation	.....	.....	2-3-3
ISYE 3100 The Professional Practice of Industrial and Systems Engineering	.....	.....	0-3-1
ENGL 3015 Public Speaking	3-0-3	.....	.....
ENGL 3020 Technical Writing	.....	3-0-3	.....
Humanities Elective	.....	.....	3-0-3
TOTALS	17-0-17	17-0-17	15-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 3702 Electrical Circuits or			
EE 3703 Electric Power Circuits	2-0-2	.....	.....
ISYE 4101 Operational Planning and Scheduling	3-3-4	.....	.....
ISYE 4102 Operations and Facilities Design	3-3-4	.....	.....
ISYE 4103 Management Information and Control Systems or			
ICS 4351 MIS Methodology or			
MGT 3050 Computer-based Management Systems	.....	3-0-3	.....
ISYE 4104-5 ISYE Design I, II	.....	0-9-3	0-9-3
ISYE 4039 Quality Control	3-0-3	.....	.....
Humanities Electives	3-0-3	3-0-3	.....
Approved Technical Electives	.....	6-0-6	6-0-6
Free Electives	.....	.....	6-0-6
TOTALS	14-6-16	12-9-15	12-9-15

ELECTIVES

ENGL 1001-2
Freshmen who waive English 1001 or 1002 as a result of English Department Placement Tests may substitute 2000-level or higher English courses that qualify as Humanities.

Humanities Electives
See "Information for Undergraduate Students," pp. 41-42, for humanities electives that satisfy the College of Engineering requirements. One such elective must be an English course.

Social Sciences Electives
Social sciences electives must include three hours of United States history, three hours of United States government, and three credit hours of social sciences. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Approved Technical Electives
A list of approved technical electives is available to all seniors in ISYE.

Health Systems Option
Industrial engineering undergraduates who wish to prepare themselves for practicing their profession in the rapidly expanding health industry may do so by enrolling in the Health Systems Option under the B.I.E. curriculum.

Health care is humanitarian, and health services are important to society; the industry is large, expensive, and in need of improvement. This specialty field is an opportunity to use modern scientific methods in the performance of a vital public service. The required health orientation is provided by a series of courses and project work. HS 3001, 3011, 4115, and 4116 satisfy the B.I.E. requirement of twelve hours of approved technical electives. The ISYE 4104-5 sequence is an individually tailored, health-oriented senior design project that provides real-world field training.

		Quarter Hours
HS 3001	Introduction to Health Systems	3
HS 3011	Hospital Functions	3
HS 4115	Health Field Applications I	3
HS 4116	Health Field Applications II	3
ISYE 4104	ISYE Design I	3
ISYE 4105	ISYE Design II	3
	Approved Elective	3
	Total	21

ELECTIVES
Approved Elective
This elective will satisfy three of the six hours of free electives in the B.I.E. curriculum and is to be selected from a list of health systems and other courses approved by the faculty.

CERTIFICATE IN HEALTH SYSTEMS
Students who successfully complete the Health Systems Option and other degree requirements will be awarded both the Bachelor of Industrial Engineering degree and a Certificate in Health Systems. These credentials signify competence to practice industrial engineering in the health industry.

Students completing requirements for other bachelor's degrees will also be awarded a Certificate in Health Systems if their transcripts include credit for the following courses: HS 3001, 3011, 4115, 4116, ISYE 3010, 3025, 3029, 3215, 4101, 4102, 4103, 4104, 4105, and a three-hour approved elective.

Courses of Instruction
INDUSTRIAL AND SYSTEMS ENGINEERING

ISYE 3010. Man-Machine Systems
3-0-3. Prerequisites: ISYE 3028, PSY 3303.
Human factors engineering and mathematical modeling of human-machine interaction in complex systems such as computers, aircraft, power generation, and process control. Emphasis on human perceptual and cognitive abilities related to interfaces.

ISYE 3014. Systems and Productivity
3-0-3. Prerequisite: ISYE 3105.
Human contributions to productivity and interaction of technical advances with human performance. Examination of impact of individual needs, leadership styles, and organizational design on productivity.

ISYE 3025. Engineering Economy
3-0-3. Prerequisite: MGT 2000 or equivalent. Limited to ISYE and HS students.
Methods of economic analysis in engineering, including decision problems, value measurement, interest relationships, criteria for decisions under certainty, risk, and uncertainty.

ISYE 3027. Applications of Probability
3-0-3. Prerequisite: MATH 1309.
Introduction to probability, emphasizing applications in science and engineering. Topics include probability concepts, random variables, discrete and continuous distributions.

ISYE 3028. Engineering Statistics I
3-0-3. Prerequisite: ISYE 3027 for ISYE students, ICS 1700 or equivalent.
Introduction to statistical methodology, emphasizing applications in science and engineering. Topics include estimation, hypothesis testing, and process control.

ISYE 3029. Engineering Statistics II
3-0-3. Prerequisite: ISYE 3028 or equivalent.
Introduction to analysis of planned and unplanned experiments. Topics include regression and analysis of variance with applications to problems in engineering and science.

ISYE 3100. The Professional Practice of Industrial and Systems Engineering
0-3-1. Prerequisite: junior standing. Limited to ISYE students.
A laboratory seminar wherein students meet industrial and systems engineering practitioners to discuss their current work problems and career progression.

ISYE 3105. Organizational Structures
3-0-3.
The organizational elements, activities, and structures within which an industrial engineer functions.

ISYE 3113. Physiological and Biomechanical Analysis of Work
3-0-3. Prerequisite: ISYE 3215.
Techniques of data collection and analysis for effective manpower-oriented tool and work place design.

ISYE 3215. Design and Measurement of Work Methods
3-0-3. Corequisite: ISYE 3029.
Introduction to principles and techniques for analysis, design, and measurement of work methods.

ISYE 3231. Deterministic Operations Research
3-0-3. Prerequisites: Math 2307 and ICS 1700.
Deterministic models and methods of operations research in solving engineering and management problems. Topics include linear models, linear programming, duality, post optimality analysis, and network analysis.

ISYE 3232. Probabilistic Operations Research
3-0-3. Prerequisite: ISYE 3027, 3231, or equivalent.
Stochastic models and methods in operations research to solve engineering and management problems. Includes queueing theory, queueing decision models, inventory models, Markov decision processes, and decision analysis under risk.

ISYE 3233. Advanced Operations Research
3-0-3. Prerequisite: ISYE 3232.
Further topics in modeling and methods for optimization. Includes advanced algorithms for linear programming, integer programming methods and applications, nonlinear programming, and dynamic programming.

ISYE 3260. Introduction to Systems Engineering
3-0-3. Prerequisite: MATH 3709.
Introduction to classical/modern system analysis and feedback dynamics as applied to industrial engineering problems. Transfer functions, state models, transient and steady state behavior, stability and compensation.

ISYE 4000. Introduction to Systems Theory
3-0-3.
The basic classical and modern concepts and tools required for modeling, analysis and synthesis of linear, discrete and continuous, deterministic and dynamic systems.

ISYE 4005. Nonlinear Programming
3-0-3. Prerequisite: ISYE 3233 or equivalent.
Solution procedures for nonlinear programs. Unconstrained optimization, gradient and gradient-free methods, constrained optimization, Lagrange multipliers, penalty functions, and linear approximation methods.

ISYE 4006. Integer and Dynamic Programming
3-0-3. Prerequisite: ISYE 3233 or equivalent.
Optimization by dynamic and integer programming. Decision trees, optimality principle, and recursive rela-

tionships. Optimization in integer by cutting planes, branch and bound and implicit enumeration.

ISYE 4022. Job Evaluation and Wage Incentives
3-0-3. Prerequisite: ISYE 3215.

Study of principles used to establish wage rates and salaries. Emphasizes characteristics and objectives of wage incentive plans and design and analysis of incentive formulas.

ISYE 4024. Fundamentals of Materials Handling
2-3-3. Prerequisites: ISYE 3025, 4102.

Development of procedures and techniques for analysis and solution of materials handling problems. Plant trips and laboratories utilized to illustrate modern materials handling methods.

ISYE 4028. Introduction to Feedback Dynamics
2-3-3.

Examination of feedback processes as causes of dynamic behavior in socioeconomic and managerial systems. Emphasizes feedback loop performance characteristics and computer simulation of multivariate nonlinear systems.

ISYE 4035. Project Management Systems Design
2-3-3. Prerequisites: ISYE 3231 and senior standing.

Project planning and control using activity network analysis. Emphasizes network logic, scheduling computations, resource scheduling, time-cost trade-off algorithms and multiproject resource allocation.

ISYE 4039. Quality Control
3-0-3. Prerequisite: ISYE 3028 or equivalent.

Design of quality control systems. Quantitative techniques for establishing product specifications, process controls, acceptance inspection, and other techniques of · quality assurance.

ISYE 4044. Simulation
2-3-3. Prerequisites: ISYE 3028, 3232.

Discrete simulation methodology emphasizing statistical basis for simulation modeling and modeling and experimentation. Overview of computer languages and continuous flow models. Laboratory exercises illustrating model architecture, inference, and optimization.

ISYE 4073. Storage and Distribution Systems Design
3-0-3. Prerequisite: ISYE 4102.

Fundamentals of designing efficient materials and product distribution systems emphasizing warehouse planning, materials and information flow, equipment selection, building design and location, automated warehousing and transportation.

ISYE 4090. Legal and Ethical Phases of Engineering
3-0-3. Prerequisite: senior standing.

Introduces the engineer to the ethical, legal, and professional attitudes to be encountered in the future working environment. Includes business, patent, and copyright law considerations.

ISYE 4101. Operations Planning and Scheduling
3-3-4. Prerequisites: ISYE 3231, 3232.

Analytical methods for production and inventory control, emphasizing forecasting techniques, inventory models, application of mathematical programming and network models, sequencing and scheduling techniques, and line balancing.

ISYE 4102. Operations and Facilities Design
3-3-4. Prerequisites: ISYE 3215, 3232.

Principles and practices in the design of operations and facilities for a productive system.

ISYE 4103. Management Information and Control Systems
3-0-3. Prerequisite: ISYE 4101.

Principles of the analysis and design of management information and control systems—especially those involving electronic data processing.

ISYE 4104. ISYE Design I
0-9-3. Prerequisites: ISYE 4101, 4044, 4102. Must be followed by ISYE 4105 in consecutive quarters. Limited to ISYE students.

Senior ISYE group design project requiring problem definition and analysis, synthesis, specification, and installation of a designed solution in off-campus enterprise environments.

ISYE 4105. ISYE Design II
0-9-3. Prerequisites: ISYE 4103, 4104. Limited to ISYE students.

Senior continuation of ISYE group design project sequence (ISYE 4104) requiring problem definition and analysis, and synthesis, specification, and installation of a designed solution.

ISYE 4145. Simulation Applications
2-3-3. Prerequisite: ISYE 4044.

Continuation and extension of ISYE 4044. Discrete-event simulation methodology with emphasis on analysis of systems and models. Input data analysis, validation, output analysis, inference, comparison of systems, optimization of systems. Advanced modeling techniques in a computer simulation language such as GPSS.

ISYE 4725. Engineering Economy
3-0-3. Prerequisite: sophomore standing. Not available to ISYE students.

Fundamental principles and basic techniques of economic analysis of engineering projects, including economic measures of effectiveness, time value of money, cost estimation, break-even and replacement analysis.

ISYE 4756. Technological Forecasting
3-0-3. Prerequisite: senior standing or consent of the School.

Emphasizes forecasting future trends and specific developments in areas of technology. Develops methodologies for identifying future functional capabilities and needs. Case histories in technological forecasting utilized.

ISYE 4757. Technology Assessment
3-0-3. Prerequisite: senior standing.

Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended, or modified. Considers concepts, organization, and uses of various specific assessment methods.

ISYE 4897-8-9. Special Topics
3-0-3. each. Prerequisite: senior standing.

Courses in special topics of timely interest to the profession conducted by resident or visiting faculty.

ISYE 4991-2-3. Special Problems
Credit to be arranged. Prerequisites: senior standing in ISYE and prior faculty topic approval.

A one- to three-hour credit opportunity to develop initiative and apply fundamental principles by performing semioriginal laboratory or research work in industrial and systems engineering.

ISYE 4994-5-6. Research and Projects I, II, III
Credit to be arranged. Prerequisite: senior standing in ISYE and prior faculty topic approval.

Research or project work in conjunction with faculty investigations, which may result in undergraduate thesis. Limited to six hours for students with less than a 3.0 cumulative point average.

ISYE 6101. Modern Organizations
3-0-3.

A comprehensive study of the theories of industrial organization, with particular emphasis on analyzing, evaluating, and integrating organizational activities.

ISYE 6103. Organizational Decision Making
3-0-3. Prerequisites: ISYE 6101, 6734.

A course integrating behavioral findings with mathematical models of the decision process. The major focus is on these processes in organizational settings.

ISYE 6107. Management of Improvement
3-0-3.

Concepts of the management of improvement endeavors, strategies and tactics for achieving continuous improvement within organizations. Theoretical bases and approaches to encourage innovation are studied.

ISYE 6214. Models of Interactive Computer Interfaces
3-0-3. Prerequisites: ISYE 3010, 6401, ICS 2100.

Models that predict and describe human behavior on interactive computer interfaces are covered. A common theme among course topics is modeling users with mechanisms. These mechanisms include optimum seeking, formal grammars, internal device models, task analyses, and human information processing.

ISYE 6215. Models of Man-Machine Interaction
3-0-3. Prerequisite: ISYE 3010 or equivalent.

The development and use of mathematical models of human behavior are considered. Approaches to modeling that are discussed include estimation theory, control theory, queueing theory, fuzzy set theory, rule-based models, pattern recognition, and Markov processes. Applications considered include flight management, air traffic control, process monitoring and control, failure detection and diagnosis, and human-computer interaction.

ISYE 6218. Work Systems Design
3-0-3. Prerequisite: consent of the School.

Advanced study of the design of work systems, with emphasis on the human operator and that role in the work system.

ISYE 6219. Human Factors Engineering
3-0-3.

Application of information on human capabilities and limitations in the design process. Design problems are used to aid understanding of application of human factors data.

ISYE 6220. Work Physiology
3-0-3.

An evaluation of the various factors affecting human physical performance in the industrial environment. Topics: anthropometry, biomechanics, energy expenditure, heat stress, fatigue, training, strength.

ISYE 6221. Man-Machine Control Systems
3-0-3. Prerequisite: consent of the School.

An introduction to the application of systems theory and methodology to the analysis and design of man-machine control systems.

ISYE 6223. Understanding and Aiding Human Decision Making
3-0-3. Prerequisite: ISYE 3010 or equivalent.

Prescriptive and descriptive theories of human decision making are discussed and contrasted. Approaches to aiding human decision making are considered in the context of these theoretical frameworks. Applications-oriented issues are emphasized.

ISYE 6224. Seminar in Man-Machine Systems Research
3-0-3. Prerequisites: ISYE 3010 or 6215.

The course explores and examines state-of-the-art research directions such as supervisory control models of human command control tasks; human-computer interface in the scheduling and supervision of flexible manufacturing systems.

ISYE 6225. Advanced Engineering Economy
3-0-3. Prerequisites: ISYE 3025, 3231.

Advanced engineering economy topics, including measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty, foundations of utility theory.

ISYE 6226. Replacement Analysis
3-0-3. Prerequisites: graduate standing, ISYE 3025, 6734, or equivalent.

Emphasis on analytical methods utilized to evaluate the economic desirability of replacement and retirement options. Use of asset records and analytical methods for estimating asset service lives.

ISYE 6301. Quality Control Systems
3-0-3. Prerequisite: ISYE 4039.

The design of quality control systems for production and service enterprises. Topics include costs of quality, quality control systems design, and evaluation of system performance.

ISYE 6302. Quality Control in Manufacturing Systems
3-0-3. Prerequisite: graduate standing.

Quality assurance in manufacturing systems and the standard statistical methods useful in designing and manufacturing high quality products. Not available for credit to students pursuing MSIE or those with credit for ISYE 4039.

ISYE 6303. Manufacturing Planning and Control
3-0-3. Prerequisite: graduate standing.

Systems and methods for planning, scheduling, and control of production in the manufacturing environment. Not available for credit towards the MSIE degree.

ISYE 6305. Forecasting Systems
3-0-3. Prerequisite: ISYE 3029 or equivalent.
Techniques and systems for forecasting time series. Statistical methods for generating short-term forecasts, analysis of forecast error, and design of forecasting systems.

ISYE 6306. Inventory Systems
3-0-3. Prerequisite: ISYE 3027, 3231, or equivalent.
An introductory course in inventory theory. Deterministic lot size models, probabilistic models of continuous and periodic review policies, dynamic models, and multi-echelon systems.

ISYE 6307. Scheduling Theory
3-0-3. Prerequisite: ISYE 6650.
Analysis of sequencing and scheduling activities. Static scheduling problems, dynamic scheduling systems, simulation studies of priority dispatching rules, priority queueing models.

ISYE 6308. Analysis of Production Operations
3-0-3. Prerequisites: ISYE 6306, 6669.
Mathematical models for production planning. Applications of mathematical programming, dynamic programming, network theory and heuristic methods to problems of planning production, inventories, and capacity.

ISYE 6400. Design of Experiments I
3-0-3. Prerequisite: ISYE 6739 or equivalent.
Analysis and application of standard experimental designs, including factorials, randomized block, latin squares, confounding and fractional replication multiple comparisons, and an introduction to response surfaces.

ISYE 6401. Applied Regression Analysis I
3-0-3. Prerequisite: ISYE 3028 or 6739 or equivalent.
Analysis of data from unplanned experiments. Emphasis on the application of statistical principles to empirical model building.

ISYE 6402. Time Series Analysis
3-0-3. Prerequisite: ISYE 3029 or equivalent.
Building empirical-stochastic models of the autoregressive moving-average form for stationary and nonstationary phenomena. Topics include identification procedures, parameter estimation, diagnostics checking, and model forecasting.
Text: at the level of Box and Jenkins, *Time Series Analysis, Forecasting and Control.*

ISYE 6404. Nonparametric Statistics
3-0,3. Prerequisite: ISYE 6739 or equivalent.
Basic concepts and applications of nonparametric statistics. Order statistics, runs, goodness-of-fit tests, one-sample, two-sample, and k-sample tests for location and scale.

ISYE 6405. Response Surfaces I
3-0-3. Prerequisite: ISYE 6400.
Introduction to response surface methodology. Topics include canonical analysis, steepest ascent, first and second order response surface designs, concepts of rotatable and uniform precision designs, orthogonal blocking.
Text: at the level of Myers, *Response Surface Methodology.*

ISYE 6406. Response Surfaces II
3-0-3. Prerequisite: ISYE 6405.
A continuation of ISYE 6405. Topics include optimal designs for fitting polynomials, experiments with mixtures, multiple response problems, mechanistic model building, and sequential designs.

ISYE 6407. Sampling Techniques
3-0-3. Prerequisite: ISYE 3029 or equivalent.
Survey sampling techniques. Topics include simple random and stratified random sampling, ration estimation, regression techniques, systematic, cluster and multistage, sampling, and sources of error.
Text: at the level of Cochran, *Sampling Techniques,* third edition.

ISYE 6427. Applied Statistical Decision Theory
3-0-3. Prerequisite: MATH 4241 or equivalent.
An intermediate-level course in statistical decision theory and its application to economic analysis and statistical decision problems. The techniques of Bayesian inference are developed and applied.   Text: at the level of Raifa and Schlaifer, *Applied Statistical Decision Theory.*

ISYE 6515. Analysis of Distribution Systems
3-0-3. Prerequisite: ISYE 4044, 4101, or equivalent.
Study of the various types of transportation systems available to enterprises for distributive services. Analysis of distribution alternatives stressed, emphasizing design of economic and control systems encountered.

ISYE 6524. Material Flow Systems
3-0-3. Prerequisites: ISYE 4101-2 or consent of the School.
Methodology useful in analyzing and designing material flow systems, with specific emphasis on warehousing systems. Emphasizes quantitative modeling.

ISYE 6650. Probabilistic Models in Operations Research.
3-0-3. Prerequisite: ISYE 3027 or equivalent.
Introduction to stochastic models and their applications. Discrete and continuous-time Markov processes. Poisson and renewal-reward processes. Elementary queueing and reliability models. Statistical estimation of model parameters.
Text: at the level of Ross, *Introduction to Probability Models,* 2nd ed.

ISYE 6656. Queueing Theory
3-0-3. Prerequisite: ISYE 6650.
Equilibrium Markov and embedded-Markov queues. Effects of order of service on waiting times. Jackson networks. Applications to production, service, and tele-communications systems.
Text: at the level of Cooper, *Introduction to Queueing Theory.*

ISYE 6669. Linear Deterministic Models in Operations Research
4-0-4. Prerequisite: ISYE 3231 or equivalent.
The optimization of linear models, including the revised, dual, and primal dual simplex methods, duality theorems, decomposition, cutting plane algorithms, and some network algorithms.

ISYE 6670. Nonlinear Deterministic Models in Operations Research
4-0-4. Prerequisite: ISYE 6669 or equivalent.
Algorithms for solving nonlinear and unconstrained and constrained problems, including penalty function methods, quadratic programming, and linearization methods. Text: at the level of Aoki, *Introduction to Optimization Techniques.*

ISYE 6671. Discrete Deterministic Models in Operations Research
3-0-3. Prerequisite: ISYE 6669 or equivalent.
The optimization of discrete deterministic models, including general enumerative methods and special algorithms for well-known discrete problems on graphs and networks.

ISYE 6679. Computational Methods in Optimization
3-0-3. Prerequisites: ISYE 6669 and a thorough knowledge of PASCAL, MODULA, or C at the level of ICS 2100.
Strategies and techniques for translating optimization theory into effective computational software. Emphasis on applications in linear, nonlinear, and integer programming, networks and graphs.

ISYE 6680. Location Theory
3-0-3. Prerequisite: ISYE 6669 or consent of School.
Applications of optimization theory to the location of facilities. Area and point location problems in discrete and continuous space are examined. Private and public sector applications are considered.

ISYE 6734. Methods of Operations Research
5-0-5. Prerequisite: MATH 2309. Corequisite: statistics.
An introduction to the methods for analytical formulation and solution of decision problems. Mathematical methods of optimization and classical operations research models are introduced. Not available for degree credit to ISYE students.

ISYE 6739. Experimental Statistics
4-0-4. Prerequisite: MATH 2308.
An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance. Not available for degree credit to ISYE students.
Text: at the level of Hines and Montgomery, *Probability and Statistics.*

ISYE 6751-2. Complex Systems Design I, II
2-4-3 each. Prerequisite: graduate standing.
This two-quarter sequence permits students from all schools to meet, form an interdisciplinary team, and carry out preliminary design of a significant complex system.

ISYE 6790. Computer Integrated Manufacturing Systems I
3-0-3. priority to CIMS students.
A broad overview of the functions, processes, and disciplines of computer integrated manufacturing.

ISYE 6791. Computer Integrated Manufacturing Systems II
3-0-3. Prerequisite: CIMS I.
An in-depth study of current issues, emerging technologies, and future developments in computer integrated manufacturing.

ISYE 6792. Computer Integrated Manufacturing Systems Seminar
1-0-1.
Guest speakers on a broad range of CIMS related topics: research, applications, and technology.

ISYE 6799. Quasi-experimental Design
3-0-3. Prerequisite: ISYE 6400.
Design, application, statistical analysis, and critical evaluation of quasi-experiments (i.e., extension of experimental design concepts into field settings that preclude ideal, randomized experiments).

ISYE 6800. Systems Research and Applications I
3-0-3. Prerequisite: ISYE 4000 or consent of the School.
Individual work and study of cases reflecting the application of the systems engineering process to the modeling, analysis, design, and implementation of various classes of man-machine, socioeconomic, and ecological systems.

ISYE 6801. Systems Research and Applications II
3-0-3. Prerequisite: ISYE 6800.
An interdisciplinary class project requiring small team organization and directed at the application of the systems engineering process to a single problem area.

ISYE 6805. Reliability Engineering
3-0-3. Prerequisites: MATH 4215, 4221, or equivalent.
Reliability prediction for nonmaintained systems, availability prediction for maintained systems, life demonstration test design, the concept of system effectiveness.

ISYE 6806. Introduction to Feedback Dynamics
3-0-3.
Philosophy of feedback causality. Methodology for formulation, analysis, and synthesis of feedback models and real implementation. Emphasis on large social systems with intangible variables. Student project.

ISYE 6807. Feedback Dynamics Principles
3-0-3. Prerequisite: ISYE 6806.
Detailed model building. Simulation by hand and DYNAMO. Study of oscillation, growth, frequency sensitivity, phasing, noise in feedback models. Model trouble-shooting and improvement. Student project.

ISYE 6808. Feedback Dynamics Applications
3-0-3. ISYE 6806, 6807 suggested but not required.
Design/modification of human organizations. Extensive student project illustrates principles presented in ISYE 6806-7 and provides exercise in creative real-system synthesis and recommendation implementation.

ISYE 6831. Advanced Simulation
3-0-3. Prerequisites: ISYE 4044, 6400.
Extension of discrete-event, digital simulation methods presented in ISYE 4044. Emphasis on model building and the design and analysis of simulation experiments for complex systems.

ISYE 6835. Simulation of Manufacturing Systems
3-0-3. Prerequisite: graduate standing or permission of the instructor.
Analysis of manufacturing processes using special and general purpose simulation languages; a variety of

manufacturing problems and their solution using simulation; presentations by practitioners; student projects.

ISYE 6841. Decision Support Systems
2-3-3. Prerequisites: ISYE 6734 or equivalent, 6739 or equivalent.

Interactive computer support of design, analysis, and decision making. Hands-on project in decision-aiding system development. APL programming language syntax and practice.

ISYE 6845. Effective Use of Interactive Computer Graphics
3-0-3. Prerequisites: ICS 2100 and graduate standing.

Proper use of color, shapes, and text to develop good graphical interfaces are taught. Human performance considerations, including appropriate perceptual and cognitive aspects, are considered.

ISYE 7000. Master's Thesis
Required of degree candidates in the master's thesis option.

ISYE 7400. Design of Experiments II
3-0-3. Prerequisite: ISYE 6400.

A continuation of experimental design stressing fractional factorials, analysis of unbalanced data, and covariance models. Topics include confounding and fractional designs, incomplete blocks, general methods for the analysis of unbalanced data, and covariance analysis.

ISYE 7401. Applied Regression Analysis II
3-0-3. Prerequisite: ISYE 6401.

A continuation of the concepts of multiple regression analysis begun in ISYE 6401. Topics include multilinearity diagnostics, biased estimation, detection of high leverage observations, robust fitting, and an introduction to nonlinear regression.

ISYE 7441. Linear Statistical Models I
3-0-3. Prerequisites: MATH 4241 and ISYE 6400.

Introduction to full rank linear statistical models, including least squares and maximum likelihood estimation, interval estimation, and hypothesis testing. Regression models are discussed.

Text: at the level of Graybill, *Linear Statistical Models.*

ISYE 7442. Linear Statistical Models II
3-0-3. Prerequisite: ISYE 7441.

A continuation of ISYE 7441 emphasizing linear statistical models of less than full rank. Balanced designs, including fixed, mixed, and random models, are stressed.

Text: at the level of Graybill, *Linear Statistical Models.*

ISYE 7656. Advanced Queueing Theory
3-0-3. Prerequisite: ISYE 6656.

For those interested in advanced work and research. Topics include imbedded Markov chain queueing models, waiting times under various queue disciplines, and current research problems.

ISYE 7671. Foundations of Optimization
3-0-3. Prerequisite: MATH 4311.

Conditions for optimality and nonlinear duality using generalized convex functions, and their use in nonlinear programming.

ISYE 7672. Optimization: Adjacent Extreme Point Methods
3-0-3. Prerequisite: ISYE 6669.

A study of current literature in adjacent extreme point methods including quasi concavity recent duality results, complementary pivot theory, quadratic and stochastic programming.

ISYE 7673. Nonlinear Programming
3-0-3. Prerequisite: ISYE 6670.

Advanced nonlinear programming topics, including general convergence theory and convergence rate. Issues connected with direction finding and step sizes, optimization of nonsmooth functions, cutting plane methods and their convergence.

Text: at the level of Zangwill, *Nonlinear Programming.*

ISYE 7674. Dynamic Programming
3-0-3. Prerequisite: ISYE 6669 or equivalent.

Advanced treatment of the elements of modern dynamic programming via the state space formalism. Problem formulation, computational aspects, and dimensionality reduction. Application to various fields.

ISYE 7675. Network Flows
3-0-3. Prerequisite: ISYE 6671.

Current literature in networks, including characterization theorems and algorithms for flow problems, flow with gains, multicommodity flows, disconnecting sets, and matching theory.

ISYE 7676. Combinatorial Optimization
3-0-3. Prerequisite: ISYE 6671 or consent of the instructor.

Principal topics include independent sets and cliques in graphs, graph coloring, trees and circuits, planarity and matching. Some complexity issues are covered as well as worst-case performance for efficient heuristics.

ISYE 7677. Integer Programming
3-0-3. Prerequisite: ISYE 6671.

The methods and applications of integer programming, including cutting plane methods, implicit enumeration, heuristic techniques, relaxations, facets, and other developments.

ISYE 7678. Decomposition Methods for Large Systems
3-0-3. Prerequisite: ISYE 6669.

Solution strategies, illustrated with examples, for handling complex systems with large numbers of variables and/or restrictions, linear and nonlinear.

ISYE 7680. Advanced Location Theory
3-0-3. Prerequisite: ISYE 6670, 6680, or consent of the School.

Theoretical aspects of location problems are emphasized, drawing upon results from linear and nonlinear programming, graph theory, and network analysis. Recent research literature is covered.

ISYE 8011-2-3. Seminar
1-0-1 each. Audit basis only.

ISYE 8100-1-2. Special Topics
3-0-3 each. Prerequisite: consent of the School.

Special topic offerings not included in regular courses.

ISYE 8561-2-3. Seminar in Operations Research
Credit to be arranged. Prerequisite: consent of the School.

Topics within the area of operations research that are of a special interest to the faculty and graduate students but are not included in regularly offered courses.

ISYE 8601-2. Projects in Operations Research
Credit to be arranged. Prerequisite: consent of the School.

This course provides, through project work, experience in the application of operations research methods to real-world systems.

ISYE 8704-5-6. Special Problems in Industrial Engineering
Credit to be arranged. Prerequisite: consent of the School.

ISYE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

ISYE 8998. Research Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.

For graduate students holding graduate research assistantships.

ISYE 9000. Doctoral Thesis

HEALTH SYSTEMS

HS 3001. Introduction to Health Systems
3-0-3. Prerequisite: junior standing.

Historical background; nature, problems, and costs of health care institutions; health resource planning, finance, health care policy, role of government; methods improvement and management engineering.

HS 3011. Hospital Functions
3-0-3. Prerequisite: junior standing.

Internal structure, functions, and management problems of hospitals, including departmental interactions, hospital and medical terminology, process flows of materials, supplies, personnel, patients, paperwork, and information.

HS 3221. Health Information Systems
3-0-3. Prerequisites: HS 3001 or 3011, ICS 1700, MGT 2000.

Hospital and medical information systems, data collection, storage, processing and reporting, file design, record structure, processing requirements, controls, report formats, medical records, and statistical audits.

HS 3331. Hospital Cost Analysis
3-0-3. Prerequisites: HS 3001 or 3011, MGT 2001.

Microeconomic analysis of health care delivery, hospital cost finding and cost analysis, evaluating financial alternatives, budget development, pricing policy, rate setting, reimbursement formulas, and cost containment.

HS 3341. Health Systems Planning
3-0-3. Prerequisite: HS 3001 or 3011.

The systems approach to health planning, policy and program decisions, functional systems specifications, recycling for compromise, systems integration, facility and manpower requirements.

HS 4115. Health Field Applications I
3-0-3. Prerequisites: HS 3001 or 3011 and ISYE 3215.

Establishing and operating a hospital management engineering program; applications of methods engineering, work measurement, sampling, job evaluation, and incentives to hospital management systems problems.

HS 4116. Health Field Applications II
3-0-3. Prerequisites: HS 3001 or 3011, ISYE 3025, 3028, 3231.

Applications of industrial engineering, operations research, and other quantitative methods to hospital management systems problems. Techniques include statistics, forecasting, managerial control, queueing, simulation, economic analysis, and optimization.

HS 6001. Introduction to Health Systems
3-0-3.

Description of the health care system and its interactive resource components, with emphasis upon accessibility, availability, distribution, and cost. Health systems inputs, processes, and outputs.

HS 6115. Health Systems Applications I
3-0-3. Prerequisites: HS 6001, ISYE 3215.

Applications of industrial engineering techniques to hospital management problems. Improving work methods, measuring performance, staffing and scheduling, job analysis, employee compensation, and dealing with variability.

HS 6116. Health Systems Applications II
3-0-3. Prerequisites: HS 6001, ISYE 3028, 3231.

Applications of operations research and other quantitative methods to hospital management problems. Forecasting, managerial control, waiting lines, facility planning, resource allocation, and information systems.

HS 6117. Health Systems Applications III
3-0-3. Prerequisites: HS 6001, ISYE 3025, MGT 6000.

Applications of economics, engineering economy, and cost accounting to hospital management problems. Case-mix methodologies, budgeting, revenue enhancement, cost containment, and governmental regulation.

HS 6231. Project Management
3-0-3. Prerequisite: HS 6001.

Principles and techniques of managing a health systems service program; project planning, direction, and control; dealing with environmental subtleties; management reporting and project implementation.

HS 6341. Health Systems Planning
3-0-3. Prerequisites: HS 6001, ISYE 3028.

Community health planning, facility master planning, health care requirements analysis, systems integration, financial planning, and life-cycle costs.

HS 6342. Community Health Systems
3-0-3. Prerequisites: HS 6001, ISYE 3028.

Planning for health care needs of a community as a system. Analysis of community structure, decision making, planner-community interactions, and accessibility barriers to services.

HS 6351. Research and Evaluation Methods
3-0-3. Prerequisite: graduate standing.

Principles and techniques of planning, proposing, conducting, evaluating, and reporting research projects. Elements of the scientific method. Critical review of theses, research reports, and publications.

HS 6571-2-3-4-5-6. Graduate Field Training
0-3-1 through 0-18-6. Prerequisite: HS 6351. Open to HS students only.

Field training for individual graduate students in relation to health care institutions, health service organizations, or health planning agencies. Graduate project, formal written report, and oral presentation. Normally part time over two or three quarters.

HS 6665. Graduate Case Studies
3-0-3. Prerequisites: HS 6001, 6115, 6116.
Applications of hospital management engineering and health systems planning techniques using examples drawn from professional practice and research reported in the literature.

HS 7000. Master's Thesis
Prerequisite: prior arrangement with the School.

HS 7665. Graduate Projects
1-6-3. Prerequisite: prior arrangement with the School.
Research projects addressed at real-life problems confronting operational health care institutions and employing modem principles and approaches of health systems analysis. Project report.

HS 8092-3. Graduate Seminars
1-0-1 each.
Guest speakers, discussions of health issues, problems and solutions, field training experiences, and employment opportunities.

HS 8161-2-3-4. Topics in Health Systems
3-0-3 each. Prerequisite: prior arrangement with the School.
Provides formal course work on special topics not included in regular health systems graduate courses.

HS 8261-2-3-4. Special Topics
1-0-1 through 4-0-4. Prerequisite: prior arrangement with the School.
Special or experimental offerings of topical coverage not included in regular health systems graduate courses.

HS 8971-2-3-4. Special Problems
Credit to be arranged. Prerequisite: prior arrangement with the School.
Individual student projects that apply systems techniques to health care management and planning problems with emphasis upon student initiative, methodology, problem solution, and written report.

HS 8997. Teaching Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

HS 8998. Research Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

School of Materials Engineering

Established in 1985, School of Ceramic Engineering established in 1924.

Director and Professor—Stephen D. Antolovich

Faculty
Georgia Power Professor—Alan T. Chapman; *Professors*—James F. Benzel, Helen E. Grenga, Robert F. Hochman, Joseph L. Pentecost, Thomas H. Sanders, Ashok Saxena, Ervin E. Underwood; *Associate Professors*—Joe K. Cochran, Jr., Miroslav Marek; *Assistant Professors*—Stuart R. Stock, James P. Schaffer; *Lecturer*—R. A. Young; *Research Engineer*—David N. Hill; *Research Scientist*—W. Brent Carter; *Adjunct Professors*—Henry Chia, Bruce G. Lefevre, Pieter Muije (emeritus).

Fracture and Fatigue Research Laboratory Director—Stephen D. Antolovich

General Information
The School of Materials Engineering was established on March 1, 1985, to provide increased focus for research and instruction on materials at Georgia Tech. The School presently comprises two components: the Ceramic Engineering Program and the Metallurgical Engineering Program. Each of these two programs is described in the following sections.

Ceramic Engineering Program
In the United States, the ceramic industry annually produces more than $40 billion worth of products, ranging from brick, tile, glass, portland cement, and dinnerware to high-temperature refractories for furnace linings, abrasives, and many sophisticated electronic components. While traditional products create a continuing demand for trained personnel, the development of new products constantly opens fresh career opportunities. Some examples of these new products from the recent past include rocket nozzles, jet engine parts, electronic circuitry for computers, and fiberglass products for

nose cones and missiles. Current developments include automotive exhaust catalyst supports and other pollution control devices, new lighting techniques, and electro-optical materials.

Ceramic engineering applies sound, scientific engineering principles to solve manufacturing problems in the industry. Because both chemical and physical reactions occur at the high temperatures used in ceramics manufacturing, the problems frequently become more complex and challenging. Measurements are difficult, and economical production imposes cost constraints.

The School of Materials Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to the Master of Science and Doctor of Philosophy degrees in ceramic engineering. The undergraduate curriculum prepares the degree candidate for a position in the ceramic industry or for graduate work. Additional courses introduce nonmajors to ceramic materials, processes, and applications.

Multidisciplinary Programs
See table on page 80.

Ceramic Engineering Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1111-2 General Chemistry	4-3-5	4-3-5	.....
CHEM 2113 Chemical Principles	.....	.....	3-3-4
EGR 1170 Visual Communication and Engineering Design	2-3-3	.....	.....
Freshman Engineering Elective	.....	X-X-3	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Physical Education (requirements, p. 253)	.....	.....	3-0-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Free Elective	.....	.....	3-0-3
TOTALS	14-6-16	14-6-16	17-3-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CERE 3101 Ceramic Data Handling	.....	.....	3-3-4
MET 3301 Principles and Applications of Engineering Materials	.....	.....	4-3-5
ESM 2201 Statics	.....	3-0-3	.....
ESM 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
GEOS 2100 General Geology	3-0-3	.....	.....
GEOS 2102 General Geology Laboratory	0-3-1	.....	.....
MATH 2307 Calculus IV	5-0-5	.....	.....
MATH 2308 Calculus and Linear Algebra	.....	5-0-5	.....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	.....
Free Elective	.....	3-0-3	.....
TOTALS	15-6-17	18-3-19	16-9-19

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CERE 3003 Ceramic Processing I	3-3-4	.....	.....
CERE 3104 Ceramic Processing II	.....	3-3-4	.....
CERE 3105 Phase Equilibria for Ceramists	3-0-3	.....	.....
CERE 3006 Physical Ceramics I	3-0-3	.....	.....
CERE 3007 High Temperature Analysis	.....	2-3-3	.....
CERE 3008 Glass Technology I	.....	2-3-3	.....
EE 3701 Electric Circuits	.....	.....	2-0-2

CERE 4042			
Seminar	.....	1-0-1	.....
CERE 4052			
Inorganic Phase Analysis and Identification	.....	.....	3-3-4
CHEM 3412-3			
Physical Chemistry	.....	3-0-3	3-0-3
CHEM 3481			
Physical Chemistry Laboratory	.....	.....	0-6-2
ME 3720			
Thermodynamics	4-0-4	.....	.....
CHE 3311			
Heat Transfer	.....	.....	3-0-3
ESM 3201			
Dynamics I			
or			
ESM 3302			
Mechanics of Materials	3-0-3	.....	.....
Humanities/Social Sciences/Modern Languages Electives	.....	3-0-3	3-0-3
TOTALS	16-3-17	14-9-17	14-9-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
CERE 4102			
Refractories	3-3-4	.....	.....
CERE 4003			
Physical Ceramics II	.....	2-3-3	.....
CERE 4004			
High Temperature Thermodynamics	.....	.....	2-0-2
CERE 4005			
Glass Technology II	2-3-3	.....	.....
CERE 4210			
Energy Conservation and Control	.....	.....	3-0-3
CERE 4043			
Seminar	.....	1-0-1	.....
ISYE 4725			
Engineering Economy	3-0-3	.....	.....
EE 3400			
Instrumentation Laboratory	1-3-2	.....	.....
EE 3703			
Electric Power Conversion	.....	2-0-2	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	6-0-6	6-0-6
Technical Elective	.....	.....	3-0-3
Free Electives	.....	6-0-6	3-0-3
TOTALS	12-9-15	17-3-18	17-0-17

ELECTIVES

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives: CERE 1010, CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

Humanities/Social Sciences/Modern Languages Electives

See Information for Undergraduate Students, "Humanities and Social Sciences Requirements," pp. 41-42. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Metallurgical Engineering Program

The field of metallurgy is a vital component of the industrial economy because of its central contribution to the selection and use of metals in all engineering and scientific fields. The program at Tech offers a master's degree in metallurgy and a doctoral degree. An excellent selection of undergraduate courses is also offered in preparation and support of graduate studies. Course offerings and research activities cover a range of subject areas in the broad field of metallurgy. Subjects include chemical and extractive metallurgy, corrosion science and engineering, physical metallurgy, mechanical metallurgy, and metallurgical processing and mineral engineering.

Research facilities are among the program's strongest features. Excellent general corrosion laboratory equipment is part of the corrosion research facilities in which hydrogen embrittlement, metal dusting, stress-corrosion-cracking, and medical implant and dental material investigations are carried out. Structural investigations of metals and alloys are performed in the X-ray laboratory that has a variety of general use equipment and in the electron microscopy laboratories that include a JEOL STEM-100C scanning transmission electron microscope. Metallographic equipment, heat treatment furnaces, and alloy-melting equipment allow investigators to design and produce new materials. Mechanical testing facilities include both standard and specialized equipment, most notably six state-of-the-art, computer-controlled closed-loop test frames in which fatigue testing can be carried out at temperatures up to $1000°$ C and vacuums of 10^{-10} torr. This equipment is used to study a wide range of materials, including metals, ceramics, and composites.

Graduates find employment with manufacturing firms in light and heavy industry, in research laboratories of private firms and federal agencies, and in academic institutions. Several recent graduates have filled positions of high responsibility in these areas and have been instrumental in advancing the level of materials engineering practice in the United States.

The Metallurgy Program faculty participate in several multidisciplinary programs, including materials engineering, mineral engineering, and manufacturing engineering, in the interdisciplinary program in surface science technology and in the Microelectronics Research Laboratory.

Fracture and Fatigue Research Laboratory

The Fracture and Fatigue Research Laboratory (FFRL) was established to encourage interdisciplinary research and educational opportunities in the field of fracture and fatigue of materials. Faculty members representing various academic disciplines at Georgia Tech, as well as staff members of the Georgia Tech Research Institute (GTRI), are involved in its activities. The research programs, which focus on the fracture and fatigue behavior of engineering materials, are interdisciplinary and based on a combined fracture mechanics-materials science point of view. Projects involving the behavior of metals, ceramics, polymers, and composites all fall within the scope of the laboratory.

Graduate students participating in FFRL research usually enroll for the master's or doctoral degree in the traditional discipline of their choice. However, they pursue course work related to a broader understanding of materials and benefit from the association with other students and faculty in the interdisciplinary setting. Students with backgrounds in materials science, metallurgy, ceramics, chemistry, physics, or any branch of engineering are encouraged to apply.

The Master's Degree

The program in metallurgy offers graduate work leading to the degree of Master of Science in Metallurgy. The student admitted for graduate work will normally have completed an undergraduate program in metallurgy or metallurgical engineering. However, students with undergraduate degrees or backgrounds in other fields (e.g., physics, chemistry, geology, and chemical, ceramic, mechanical, nuclear, or geological engineering) may qualify by taking certain minimum prerequisites during the early part of their graduate studies. To assure a smooth transition into the graduate Metallurgy Program, the student should select appropriate electives during his or her undergraduate studies.

The Master of Science in Metallurgy curriculum offers two options: (1) physical metallurgy and (2) chemical metallurgy. Both have a common core of basic studies but differ in other aspects. Specialization in one of these areas does not alter the Master of Science degree. The student must prepare the individualized program of study for this degree in conference with his or her graduate adviser. The proposed program must receive the approval of the graduate adviser and the director and will include a thesis.

Physical Metallurgy

This option deals with the relationships between chemical composition, structure, and properties of metals and alloys. Activities of the physical metallurgist include the study of atomic structure of solids, alloy development, and the mechanical, physical, and corrosion behavior of metals and alloys in engineering applications.

Chemical Metallurgy

This option deals with the concentration of minerals from natural resources and the extraction of pure metal from these concentrates. Recycling of metal scrap and other waste products is also a specialty of the chemical metallurgist. The industries that usually require the services of the chemical metallurgist are iron, steel, aluminum, cop-

per, and other basic metal producers. In addition, the chemical metallurgy option deals with the fundamental characteristics of metal and alloy deterioration (corrosion) and the properties and structures of metal surfaces (surface science) in liquid and gas environments.

The Doctoral Degree

The Doctor of Philosophy degree is directed toward the goal of attaining proficiency in the conduct of independent scholarly work. The degree program comprises course work in the principles of metallurgy, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination, and an independent research investigation.

Except for the requirement that the student must earn fifteen credit hours in a minor field, which may be any technical or non-technical field that he or she chooses, there are no definite course requirements for the doctoral degree in metallurgy. Most students find that they will schedule about sixty to seventy hours of courses.

Students should commence participation in the School's research programs early in their graduate careers. The undertaking of a doctoral thesis is usually reserved until the candidacy examination is passed, usually the second graduate year for a well-prepared student.

Financial Aid

A number of fellowships and research assistantships from outside sources and industry are available to provide financial assistance for qualified graduate students. In addition, a limited number of Presidential Fellowships, as well as teaching and research assistantships, are available from the Institute. Waiver of out-of-state tuition is possible for qualified students. Further information can be obtained by writing the director of the School of Materials Engineering.

Courses of Instruction

CERAMIC ENGINEERING

CERE 1101. Introduction to Ceramic Engineering
1-0-1. Elective for freshmen.
An orientation to ceramic engineering. The nature of ceramic materials and applications and processing of these materials. Role of the ceramic engineer in industry. The ceramic engineering curriculum at Georgia Tech.

CERE 3003. Ceramic Processing I
3-3-4. Prerequisite: CHEM 1102 or equivalent.
The processing of ceramic raw materials for use in plastic forming processes is studied. Mining practice, comminution, beneficiation, particle size analysis and classification and rheology of slurries are covered in detail. Text: at the level of Jones, *Ceramics, Industrial Processing, and Testing;* Norton, *Elements of Ceramics.*

CERE 3006. Physical Ceramics I
3-0-3. Prerequisite: CERE 3002.
Crystal chemistry concepts are developed and used to characterize silicate, oxide, and nonoxide ceramic materials.
Text: at the level of Kingery, *Introduction to Ceramics.*

CERE 3007. Pyrometry and Thermal Analysis
2-3-3. Prerequisite: PHYS 2122.
Temperature measurement using thermocouples, optical pyrometers, and radiation pyrometers is emphasized. Differential thermal analysis, thermogravimetric analysis, and dilatometry is presented for characterization of ceramic materials.
Text: At the level of *Precision Measurement and Calibration,* volume two; NBS Special Publication 300, *Temperature.*

CERE 3008. Glass Technology I
2-3-3. Prerequisite: CERE 3105 or consent of the School.
The fundamentals of glass structure, composition, manufacturing, properties, and applications are described. In the laboratory many glass batches are melted and analyzed.
Text: at the level of Hutchins and Harrington, *Glass* (reprint from volume 10, *Encyclopedia of Chemical Technology,* second edition, pp. 533-604, J. Wiley, 1966).

CERE 3101. Ceramic Data Handling
3-3-4.
Study of testing, rational economic value of test results, basis of test selection, interpretation of results, data analysis, statistical methods, computer methods, reporting.

CERE 3104. Ceramic Processing II
3-3-4.
Synthesis and characterization of reactive ceramic powders, effects of powder characteristics on green and fixed properties, and forming techniques utilizing these materials.

CERE 3105. Ceramic Phase Equilibria
2-3-3. Prerequisite: CHEM 1102 or 1112.
Interpretation of phase equilibria in nonmetallic one-, two-, and three-component systems. Use of phase diagrams in the processing of ceramic materials is discussed.

CERE 4003. Physical Ceramics II
2-3-3. Prerequisites: CERE 3006, PHYS 2123, CHEM 3413.
Densification sintering and reaction kinetics active in ceramic materials are considered. The resultant physical, mechanical, electric, and magnetic properties are related to the atomic and macroscopic structure representative of ceramic products.
Text: at the level of Kingery, *Introduction to Ceramics.*

CERE 4004. High Temperature Thermodynamics
2-0-2. Prerequisite: CHEM 3412.
Chemical thermodynamics data is used to produce reaction directions and study vaporization processes. The use of various gas mixtures to control oxygen pressures is also described.

CERE 4005. Glass Technology II
2-3-3. Prerequisite: CERE 3008.
Compositions of low, moderate, and high temperature coatings are studied to learn basis of glass properties, adherence, color, opacification, and texture.
Text: at the level of C. W. Parmelee, *Ceramic Glazes.*

CERE 4042-3. Seminar
1-0-1. Prerequisite: junior standing.
Discussion of current ceramic and scientific literature and reports of investigations.

CERE 4051. Cements
2-3-3. Prerequisite: CERE 3105.
Includes the required properties of raw materials, processing, and the hydraulic properties of cements. Portland, magnesia, high alumina, dental, and gypsiferous cements are included.
Text: at the level of Bogue, *The Chemistry of Portland Cement,* or Lea, *The Chemistry of Cement and Concrete.*

CERE 4052. Inorganic Phase Analysis and Identification
3-3-4. Prerequisite: PHYS 2122.
Provides the student with the tools to identify a ceramic material using both atomic structure-related techniques and elemental identification. Use of optical crystallograph, X-ray diffraction, transmitted and reflected light microscopy and electron microscopy are emphasized as tools to identify ceramic material phases and elemental composition.
Text: at the level of Bloss, *An Introduction of the Methods of Optical Crystallography,* and Cullety, *Elements of X-ray Diffraction.*

CERE 4053. Technical Ceramics
2-3-3. Prerequisites: CERE 3105, PHYS 2122.
Fabrication requirements, property control and structure-property-processing relationships, ceramic dielectrics, ferrites, ferroelectrics, piezoelectrics emphasized.
Text: at the level of F. H. Norton, *Fine Ceramics,* and E. C. Henry, *Electronic Ceramics.*

CERE 4054. Process and Temperature Control Instrumentation
3-3-4. Prerequisites: CERE 3101, 3004, or consent of the School.
The mathematical and physical basis for the PID control algorithm is covered. Analog and digital temperature instrumentation is explained.

CERE 4102. Refractories
3-3-4. Prerequisites: CERE 3006 and CHEM 3412.
Fundamentals of refractory materials selection and application are stressed. The raw materials for manufacturing refractories and heat transfer through refractory walls are covered.

CERE 4115. Independent Research Project I
1-0-1. Prerequisite: senior standing in Ceramic Engineering.
Each senior conducts an original investigation on an approved ceramic subject under the supervision of the instructor in charge. The object of this course is to place students on their own initiative and to coordinate the knowledge they have previously acquired.

CERE 4116. Independent Research Project II
0-3-1. Prerequisite: CERE 4115.
The senior student formulates an experimental plan under supervision of his or her adviser, assembles equipment and materials, and begins actual laboratory experimentation.

CERE 4117. Independent Research Project III
0-6-2. Prerequisite: CERE 4116.
Completion of all laboratory work on investigation, submission of preliminary write-up one month before end of quarter, and final submission of approved write-up in acceptable format one week before examination week.

CERE 4210. Energy Conversion and Control
3-0-3.
Principles involved in converting various energy sources to thermal energy needed to heat kilns and furnaces are studied. Energy conversion equipment is reviewed. Methods of energy control are detailed.

CERE 4801-2-3-4-5. Special Topics
1 through 5 credit hours, respectively.
Prerequisite: consent of the School.
New developments in ceramic materials, specialized independent study on topics of current interest.

CERE 6002. Refractories, Selection and Application
3-3-4.
Fundamentals of refractory materials selection and application are stressed. The raw materials for manufacturing refractories and heat transfer through refractory walls are covered.

CERE 6003. Physical Ceramics
2-3-3.
Structural imperfections, diffusion, sintering, and reaction kinetics of ceramic systems are considered. The resultant physical, mechanical, electric, and magnetic properties are related to atomic and macroscopic structures.

CERE 6004. Thermodynamics Applied to Ceramics
2-0-2.
The laws of thermodynamics are applied to ceramic processes and materials. The influence of oxygen pressure on nonstoichiometric compounds is emphasized.

CERE 6011. Colloidal Properties of Hydrous Alumino Silicates
3-0-3. Prerequisite: consent of the School.

The physiochemical properties of the plastic and nonplastic hydrous alumino silicate are studied, including viscosity, dispersion, flocculation, and permeability.

Text: at the level of Van Olphen, *An Introduction to Clay Colloid Chemistry.*

CERE 6012. Colloidal Properties of Hydrous Alumino Silicates
3-3-4. Prerequisite: consent of the School.

Plastic properties of clay-water systems and industrial applications. Interactions of clay and organic compounds.

Text: at the level of Lawrence, *Clay-Water Systems.*

CERE 6013. Colloidal Properties of Hydrous Alumino Silicates
3-0-3. Prerequisite: consent of the School.

Basic surface properties are studied for application to gas absorption surface area measurements and mineral flotation processes.

CERE 6014-5. Ceramic Applications to the Phase Rule
3-0-3. Prerequisite: CERE 3105 or consent of the School.

Phase equilibria in one-, two-, and three-component systems reviewed. Melting and solidification behavior in complex three-component systems examined. Effect of oxygen pressure on phase relations in multicomponent systems surveyed. Applications of thermodynamics to phase diagrams.

CERE 6017-8. Glass Technology I, II
3-0-3 each.

Constitution of glass is studied, using dynamic considerations. The reasons for the failure of oxide melts to crystallize on cooling are emphasized. Mutual polarization of ions is utilized in analyzing the various glass structures. The different experimental techniques available to study glasses are reviewed.

Text: at the level of Doremus, *Glass Science.*

CERE 6030. Crystal Structure of Materials I
3-0-3. Prerequisite: consent of the School.

Basic crystal structures and relation of different chemical compounds with similar crystal structures. Structures of various clays and complex oxides.

Text: at the level of Evans, *Crystal Chemistry,* and Wells, *Structural Inorganic Chemistry.*

CERE 6031. Crystal Structure of Materials II
3-0-3. Prerequisite: consent of the School.

Relationship of crystal structure to chemical, physical, and optical properties of high temperature inorganic materials.

CERE 6035. Research and Control Methods
2-3-3. Prerequisite: consent of the School.

Emphasis on the experimental and instrumental techniques for research and control measurements. Review of optical, physical, electrical, mechanical measurement techniques, instrumentation, laboratory demonstration.

Text: at the level of Wilson, *Introduction to Scientific Research,* and Ackoff, *Scientific Method.*

CERE 6041. Crystal Studies
2-6-4. Prerequisite: CERE 4003 or consent of the School.

Fundamentals, methods, and instruments used in X-ray diffraction studies of materials.

Text: at the level of Azaroff, *Elements of X-ray Crystallography.*

CERE 6052. Quantitative Optical and X-ray Crystallography
3-3-4.

Interaction of light and X-rays with periodic crystal lattices is developed in relation to structive identification and quantitative analysis in polycrystalline and monotalline ceramics.

CERE 6053. Electronic and Technical Ceramics
3-3-4.

Processing, properties, and structure of dielectrics, piezoelectrics, ferroelectrics, ferrites, garnets, and other technical ceramics.

CERE 6054. Digital Temperature Instrumentation and Control Systems
2-3-3.

Process control theory is reviewed. Analog and digital instrumentations are compared. Digital control algorithms for simple loops, cascaded loops, and distributed control are discussed.

CERE 6055. Refractory Failure Analysis
2-3-3.

Methods of determining the reason for premature failure of refractories in service are presented. Detailed case studies will be discussed and evaluated in the laboratory.

CERE 6056. Practical Electron Microscopy
2-3-3.

The various types of electron microscopes and how they function will be discussed. The usage of SEM techniques to investigate solid materials will be emphasized.

CERE 6110. Kiln and Furnace Design
2-3-3.

Principles, methods, and devices used to provide heat for operating kilns and furnaces are reviewed. Principles of automatic control are covered. Student designs a kiln equipped with an automatic control system.

CERE 7000. Master's Thesis

CERE 8102-3-4-5-6-7-8-9. Special Topics
Credit to be arranged.

Specific, well-defined study and measurement problems will be considered and approved for credit upon completion.

CERE 8112-3-4-5-6-7-8-9. Special Topics
Credit to be arranged.

Specific, well-defined study and measurement problems will be considered and approved for credit upon completion.

CERE 8501-2-3. Special Problems
Credit to be arranged.

CERE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

CERE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate research assistantships.

CERE 9000. Doctoral Thesis

METALLURGICAL ENGINEERING

MET 3301. Principles and Applications of Engineering Materials
4-3-5. Prerequisites: CHEM 1102 or 1112, 2113, PHYS 2123.

The principles of engineering materials directed toward their application in engineering design. Equilibrium and nonequilibrium structures and properties. Corrosion. Engineering application and failure analysis.

Text: at the level of Van Vlack, *Materials for Engineering.*

MET 3325. General Metallurgy
3-0-3. Prerequisites: CHEM 1102, PHYS 2121.

Introductory physical metallurgy and characteristics and engineering applications of cast irons and steels. Static and dynamic properties of metals and alloys. Not open to students in the School of Chemical Engineering.

Text: at the level of Keyser, *Materials Science of Engineering.*

MET 4110. Mineral Engineering: Introduction to Formation and Accumulation of Mineral Resources
3-0-3.

The processes of formation and accumulation of ores. Industrial minerals, rocks, and fuels and an introduction to mining and beneficiation.

MET 4112. Mineral Engineering: Introduction to Mineral Economics
3-0-3.

Factors pertaining to the economics of the mineral industries and theoretical and pragmatic concerns in the utilization of mineral resources.

MET 4114. Mineral Engineering: Introduction to Mining
3-0-3. Prerequisite: consent of the School.

Evaluation of mining sites; surface and underground mining methods and related equipment. Coal, ores, and industrial minerals and rocks. Safety and environmental aspects of mining.

MET 4115. Mineral Engineering: Economics of the Mineral Industries
3-0-3. Prerequisite: consent of the School.

Mineral property titles and concessions, valuation, acquisition and operating costs, marketing, taxation, environmental considerations, and the role of minerals in industrialized nations.

MET 4116. Mineral Engineering: Separation Technology
3-0-3. Prerequisite: junior standing.

A study of the processes for separating mine products and other materials and solid fuels; crushing, grinding, volumetric sizing, classifying, and concentration.

MET 4403. Introductory Nuclear Metallurgy
3-3-4. Prerequisites: CHEM 1102, PHYS 2123.

Fundamentals of physical metallurgy, metal crystals, phase diagrams, properties, fabrication, and testing, with emphasis on metals used in nuclear reactor systems. Primarily for NE students. Not open to CHE students.

MET 4411. Basic Extractive Metallurgy
3-0-3. Prerequisite: CHEM 3413 or equivalent.

Theory and practice of extraction and refining of ferrous and nonferrous metals. Calculations and reactions related to pyrometallurgical and hydrometallurgical extractive processes will be emphasized.

Text: at the level of Gilchrist, *Extraction Metallurgy.*

MET 4421. Nonferrous Metallography
2-3-3. Prerequisite: MET 3301 or equivalent.

The influence of processing variables on the structure and properties of nonferrous alloys. Pyrometric instrumentation applied to heat treating and thermal analysis.

Text: at the level of Gordon and Phillips, *Structure and Properties of Alloys.*

MET 4422. Ferrous Metallography
3-3-4. Prerequisites: MET 3301, 4421, or equivalent.

The influence of processing variables on the microstructure and properties of steels and ferrous alloys. Heat treating and thermal analysis of ferrous materials.

Text: at the level of Brick, Gordon, and Phillips, *Structure and Properties of Alloys.*

MET 4423. Metallurgical Fabrication
3-0-3. Prerequisite: MET 3301 or equivalent.

Primary forming techniques and secondary fabrication and joining processes. Some of the processes to be discussed are casting, rolling, forging, extrusion, drawing, machining, and welding.

MET 4441. Theoretical Physical Metallurgy
3-0-3. Prerequisite: MET 3301 and CHEM 3413 or equivalent.

A study of the physical and mechanical properties of metals and alloys in the light of their structure.

Text: at the level of Cottrell, *An Introduction to Metallurgy.*

MET 4445. Electron Microscopy
2-3-3. Prerequisites: MATH 2308 and MET 3301. Recommended course: MET 4446 or CERE 6041 or equivalent.

Theory and principles of electron optics and electron microscopy. Preparation and observation of materials by transmission electron microscopy.

Text: at the level of Loretto, *Electron Beam Analysis of Materials.*

MET 4446. X-ray Metallography
3-3-4. Prerequisite: MET 3301.

Theory and application of X-ray diffraction to materials.

Text: at the level of Cullity, *Elements of X-ray Diffraction,* 2d. Ed., and Azaroff and Donahue, *Laboratory Experiments in X-ray Crystallography.*

MET 4463. Metallurgical Testing
2-3-3. Prerequisite: MET 3301.

Stress-strain relationships. Elastic and plastic deformation. Elementary dislocation concepts. Laboratory experiments include tension, creep, fatigue, impact, and hardness testing. Metallic, ceramic, plastic, and filamentary materials.

Text: Dieter, *Mechanical Metallurgy,* 2d Ed.

MET 4464. Nondestructive Testing
2-3-3.
Principles and theory of industrial nondestructive testing methods. Emphasis on testing the soundness and reliability of primary and secondary fabricated metal structures.
Text: *Nondestructive Testing Handbook.*

MET 4491. Corrosion and Protective Measures
3-0-3. Prerequisites: CHEM 3413 and MET 3325 or 3301.
The electrochemical theory of corrosion, recommended materials, and protective measures for chemical processing equipment and for atmospheric, underground, underwater, and elevated temperature exposures.
Text: Scully, *The Fundamentals of Corrosion.*

MET 6005. Dental-Medical Materials
2-0-2. Prerequisites: MET 3301 and 4491.
Theoretical requirements and compatibility of metals as medical implants and a review of up-to-date research. Special lectures will be given by visiting researchers.

MET 6011. Pyrometallurgy
3-0-3. Prerequisite: MET 4411 or equivalent.
Pyrometallurgical processes for the production or recycling of ferrous and nonferrous metals.

MET 6012. Hydrometallurgy
3-0-3. Prerequisite: MET 4411 or equivalent.
Hydrometallurgical processes used in the production of copper, aluminum, zinc, uranium, and other metals.

MET 6014. Electrometallurgy
2-3-3. Prerequisite: CHEM 3413 or equivalent.
Electrolytic dissolution and deposition of metals, electrolytic purification, electroplating, anodizing, and electropolishing.

MET 6021. Metallurgical Design Problems
1-6-3. Prerequisite: full graduate standing.
Selection of process equipment, design of special equipment, plant layouts and preparation of equipment, utilities. Production costs. Design methods are discussed, evaluated, and utilized.

MET 6025. Powder Metallurgy
1-3-2. Prerequisite: MET 4423.
Physical and chemical production of metallic powders. Pressing, slipcasting, sintering, and the theoretical aspects of these processes. Hot pressing and coining. Industrial applications and materials.
· Text: at the level of *ASM Powder Metallurgy*, selected literature by Steinburg, Kuczynski, and Schwarzkopf.

MET 6033. High Temperature Metallurgy
2-0-2. Prerequisites: MET 3301, 4491.
Effects of temperature on properties and microstructures. Deformation mechanisms, theories, and phenomenological relationships. Grain boundary sliding, migration. Constitutive equations, deformation mechanism maps, time-temperature parameters.
Text: at the level of F. Garofalo, *Fundamentals of Creep-Rupture in Metals.*

MET 6035. Advanced Nuclear Materials
3-0-3. Prerequisite: MET 4403 or equivalent.

Physical metallurgy of alloys used in fission and fusion reactor systems. Response of materials to irradiation. Creep, fracture, and corrosion. Design of new alloys.

MET 6091. Advanced Theory of Metallic Corrosion
3-3-4. Prerequisite: MET 4491.
The subject matter covers the latest theories and concepts of metallic corrosion.

MET 6421. Quantitative Characterization of Microstructures
3-0-3. Prerequisite: graduate standing or consent of the instructor.
General, statistically exact methods for describing geometrical attributes of microstructures from random sections. Applications to actual materials or biological specimens. Manual and automatic image analysis techniques.
Text: Underwood, *Quantitative Stereology.*

MET 6787. Heterogeneous Catalysis
3-0-3.
Physical chemistry of surfaces; thermodynamics, kinetics and mechanisms of chemisorption and surface reactions, industrial catalysts. Also taught as CHE 6787.
Text: at the level of Satterfield, *Heterogeneous Catalysis in Practice.*

MET 7000. Master's Thesis
Credit to be arranged.

MET 7041. Advanced Physical Metallurgy I
3-0-3. Prerequisites: CHEM 3411 or equivalent, MET 4441.
Thermodynamic and solid state of metals and alloys. Phase stability. Systems for prediction of properties. Lattice dynamics. Electronic properties.
Text: at the level of W. Hume-Rothery, *Atomic Theory for Students of Metallurgy.*

MET 7045. Advanced Electron Microscopy I
3-0-3. Prerequisite: MET 4445.
This course will emphasize the dynamical theory of image contrast in thin crystalline foils and its application to the interpretation of lattice defects.
Text: at the level of L. Reimer, *Transmission Electron Microscopy.*

MET 7046. Advanced Electron Microscopy II
3-0-3. Prerequisites: MET 4445, 7045.
This course will emphasize the application of theories of electron diffraction and image contrast in thin foils to the types of problems commonly encountered in materials.
Text: at the level of L. Reimer, *Transmission Electron Microscopy.*

MET 7051. Advanced Mechanical Metallurgy
3-0-3. Prerequisite: MET 4463.
Basic elasticity theory. General elasticity equations. Applications to dislocations; stresses, forces, displacements, interactions, energies. Origin, multiplication, and movement of dislocations. Single-phase, two-phase, and particle strengthening.
Texts: J. Weertman and J. R. Weertman, *Elementary Dislocation Theory;* D. Hull, *Introduction to Dislocations.*

MET 7052. Advanced Dislocations and Strengthening Mechanisms I
3-0-3. Prerequisite: MET 7051.
The emphasis in this course will be on dislocation networks and their effect on the mechanical behavior of materials, including both monotonic cyclic properties.
Texts: Thompson, *Work Hardening in Tension and Fatigue;* selected literature.

MET 7053. Advanced Dislocations and Strengthening Mechanisms II
3-0-3. Prerequisite: MET 7052.
The emphasis in this course will be the interaction of dislocations with other defects and the correlation of these interactions with the mechanical properties of materials including environment's effect on fractures.
Texts: Hertzberg, *Deformation and Fracture Mechanics of Engineering Materials;* American Society for Metals, *Fatigue and Microstructure;* selected current literature.

MET 7062. Magnetism in Metals
3-0-3. Prerequisites: PHYS 6231, MET 4441, 7081.
Magnetism in materials. Electron theory, statistical and thermodynamic interpretation of ferro-, antiferro-, and helimagnetism. Ferromagnetism in metals and alloys. Domain theory of hysteresis behavior. Anisotropy and magneto-stricktion. Magnetic measurements.

MET 7068. Neutron Diffraction
3-0-3. Prerequisites: PHYS 6231, MET 4441, 4446.
Neutron scattering properties. Neutron diffraction techniques. Analysis of alloy and magnetic structure. Simple structural systems. Reciprocal space and Fourier transform methods. Inelastic scattering by phonons and magnons.
Text: at the level of Bacon, *Neutron Diffraction*, 2nd ed.

MET 7081. Metallurgical Thermodynamics
3-0-3. Prerequisites: MET 4441, CHEM 3412.
Chemical thermodynamics of metals, alloys, and metallurgical processes. Chemical equilibrium. Solution thermodynamics. Phase equilibria.
Text: Gaskell, *Introduction to Metallurgical Thermodynamics.*

MET 7085. Metallurgical Kinetics
3-0-3. Prerequisite: MET 7081.
Heat and mass transport. Empirical kinetics. Phase transformations. Diffusion mechanisms. Nucleation. Growth. Solidification. Recrystallization. Precipitation. Spinodal decomposition. Decomposition of austenite. Radiation damage.

MET 8001-2-3. Seminar
2-0-1 each. Prerequisite: graduate standing.
The latest advances in metallurgical research and development will be presented by the enrolled students from articles in recent issues of recognized periodicals.

MET 8100. Special Topics in Advanced Physical Metallurgy
3-0-3. Prerequisite: consent of the School.
Representative subjects include alloy theory, phase transformations, magnetic and electric phenomena in metals, and special topics in diffraction analysis.

MET 8500. Special Problems (Master's)
Credit to be arranged.

Lectures, laboratory, and library work on special topics of current interest in metallurgy suitable for a master's candidate.

MET 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

MET 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

MET 9000. Doctoral Thesis
Credit to be arranged.

George W. Woodruff School of Mechanical Engineering
Established in 1888

Director and Professor—John A. Brighton.

Mechanical Engineering Faculty Parker H. Petit Chair for Engineering in Medicine—Robert M. Nerem; *Georgia Power Professor and Regents' Professor*—S. Peter Kezios; *Regents' Professors*—Don P. Giddens, Allan D. Pierce, Ward O. Winer; *Professors*—William Z. Black, Wayne J. Book, Gene T. Colwell, Stephen L. Dickerson, Pandeli Durbetaki, Robert E. Fulton, Jerry H. Ginsberg, Jacek Jarzynski, Jorn Larsen-Basse, Alan V. Larson, George M. Rentzepis, Peter H. Rogers; *Associate Professors*—J. Narl Davidson (Associate Director for Undergraduate Programs and Administration), Prateen V. Desai, Thomas L. Eddy, James G. Hartley (Associate Director for Graduate Studies), Sheldon M. Jeter, Harold L. Johnson, Prasanna V. Kadaba, John G. Papastavridis, Samuel V. Shelton, Charles G. Speziale, Raymond P. Vito, William J. Wepfer; *Assistant Professors*—Yves Henri Berthelot, Jonathan S. Colton, Helen M. Cox, Robert B. Evans, Also A. Ferri, Itzhak Green, David N. Ku, Kok-Meng Lee, Harvey Lipkin, Geoffrey L. Main, David L. McDowell, Carolyn W. Meyers, J. Scott Patton, Benson H. Tongue, Charles Umeagukwu, Wendell M. Williams; *Adjunct Professors*—John T. Berry, Roy M. Scruggs; *Instructors*—James W. Brazell,

Robert Newman; *Research Engineers I*—George M. Fadel, Bruce Holway, David P. Lyons, Roger L.T. Oehmke; *Senior Research Engineer*—Scott S. Bair: *Research Scientist I*—Gary P. Schwaiger; *Research Technologist I*—Harry L. Vaughan; *Research Technologist II*—Robert T. Murray.

Nuclear Engineering and Health Physics Faculty
Chairman and Callaway/Regents' Professor—Weston M. Stacey, Jr.; *Regents' Professor*—Geoffrey G. Eichholz; Frank H. Neely; *Professor*—Melvin W. Carter; *Professors*—Joseph D. Clement, Monte V. Davis, Don S. Harmer, Bernd Kahn, John M. Kallfelz, Ratib A. Karam, Alfred Schneider; *Associate Professors*—Alan E. Levin, Patton H. McGinley (adjunct), C.E. Thomas, Jr.; *Assistant Professor*—A. Bruce DeWald.

General Information

Mechanical engineering was the first academic program established at Georgia Tech. On September 20, 1985, the School of Mechanical Engineering celebrated its centennial by assuming the name of one of its most distinguished alumni, Atlanta businessman and philanthropist George W. Woodruff (Class of 1917). Today the Woodruff School offers studies not only in mechanical engineering but also in the related fields of nuclear engineering and health physics.

Mechanical Engineering Program

Mechanical engineering traditionally deals with a large diversity of engineering problems. Because of this general nature, mechanical engineering allows a number of multidisciplinary activities to be conveniently organized within it.

Mechanical engineering embraces the generation, conversion, transmission, and utilization of thermal and mechanical energy; the design and production of tools and machines and their products; the consideration of fundamental characteristics of materials as applied to design; and the synthesis and analysis of mechanical, thermal, and fluid systems, including the automation of such systems. Design, produc tion, operation, administration, economics, and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, emphasizes basic principles, and educates the student in the use of these principles to reach optimal design solutions for engineering problems. Specific design subject matter and materials are also drawn from engineering activities such as solar energy and biomechanical systems as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics. Students must pass all required mathematics courses with a grade of *C* or better. The junior and senior years are devoted to the strength of materials and metallurgy, applied mechanics, heat transfer, fluid mechanics, systems and controls, design, and the application of fundamentals to the diverse problems of mechanical engineering. The curriculum stresses laboratory work and design projects. A strong background in FORTRAN, particularly the successful completion of ME 2016, is a prerequisite for all junior and senior level courses. Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering.

Optional Programs

Although the structure of the curriculum meets the general educational goals of the majority of mechanical engineering students, the School regularly considers and approves modifications of the basic program to allow a student with certain well-conceived educational objectives to pursue minor fields within the School or within Georgia Tech while earning a degree in mechanical engineering. In this way, a student may achieve his or her basic degree in mechanical engineering while specializing in any one of a large number of other fields. The student who follows the regular M.E. curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his or her educational goals and special interests.

Graduate Programs

The George W. Woodruff School of Mechanical Engineering has a vigorous, rapidly expanding program of advanced study and research in the areas of acoustics and noise control, applied mechanics, automatic controls, bioengineering, combustion, computer integrated and controlled manufacturing systems, dynamics and vibration, energy engineering, engineering design, environmental quality control, flammability, fluid mechanics, fluidics and fluid power, heat transfer, lubrication, magnetogasdynamics and plasmas, computer-aided design, computer-aided manufacturing, manufacturing engineering, materials processing, materials science, mechanisms (synthesis and analysis), plasma engineering, rheology, robotics, solar power, vehicle propulsion, thermal systems, thermodynamics, transport processes, turbomachinery, and two-phase flows.

These graduate programs lead to the degrees Master of Science in Mechanical Engineering, Master of Science, and Doctor of Philosophy for qualified graduates having backgrounds in engineering, mechanics, mathematics, the physical sciences, and the biological sciences.

The master's degree requires a minimum of forty-five approved credit hours. Students may elect to earn fifteen of these hours by writing a thesis, or they may earn all credit toward the degree through course work.

Multidisciplinary Programs

Mechanical Engineering is particularly active in the Computer Integrated Manufacturing Systems (CIMS) Program, an opportunity for graduate study in the integration of design, information and material processing, and management in manufacturing systems. Financial support is available to highly qualified students in the form of the IBM assistantships in CIMS. Industry interaction and unique laboratory opportunities are available in the program. For a complete description of CIMS and other multidisciplinary programs, see page 83.

School Facilities

The Woodruff School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of acoustics, bioengineering, lubrication and rheology, material processing, fire hazard and combustion, magnetogasdynamics, energetics, fluidics and fluid power control, heat transfer, vibration and thermal stress, computer-aided design, automatic control, machinery, microprocessor applications, manufacturing automation, noise, plasmas, robotics, and other areas. The School is housed in a four-building classroom/research complex. Part of this complex is a modern classroom/seminar conference building that serves the entire Institute.

The buildings of the School house many remote terminals linked to the main campus research and teaching computer; also provided are extensive microcomputer facilities. The machine and instrumentation shops, supported by a full-time staff of technicians, enhance the School's research activities.

Students may obtain additional information about the programs by requesting the *Guide to Student Life* or the *Graduate Student Information Brochure* or by calling the School at (404)894-3203. Every student enrolled must consult these sources of information with respect to special rules and degree requirements.

Bachelor of Mechanical Engineering Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2			
General Chemistry	4-3-5	4-3-5	.....
PHYS 2121			
Particle Dynamics	.....	.....	4-3-5
MATH 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170			
Visual Communication and Engineering Design	2-3-3	.....	.....
Freshman Engineering Elective	.....	.....	X-X-3
ENGL 1001-2			
Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3

Course	1st Q.	2nd Q.	3rd Q.
Physical Education (requirements, p. 253)	.....	X-X-3	.....
TOTALS	14-6-16	X-X-16	X-X-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3308 Differential Equations	.....	.....	5-0-5
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics I	.....	.....	3-0-3
ESM 3301 Mechanics of Deformable Bodies	.....	5-0-5	.....
ME 2016 Computer Applications	.....	.....	2-3-3
EE 3701 Electric Circuits	.....	.....	2-0-2
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Elective	3-0-3	.....	.....
TOTALS	18-3-19	17-3-18	15-3-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ME 3322-3 Thermodynamics	3-0-3	3-0-3	.....
ME 3340 Fluid Mechanics I	.....	3-0-3	.....
ME 3345 Conduction and Radiation Heat Transfer	3-0-3	.....	.....
ME 3347 Fluid Flow and Convection	.....	.....	3-0-3
MET 3301 Engineering Materials	4-3-5	.....	.....
EE 3702 Elementary Electronics	.....	2-0-2	.....
EE 3703 Electric Power Conversion	.....	.....	2-0-2
EE 3400 Instrumental Laboratory	1-3-2	.....	.....
EE 3421 Junior Electrical Engineering Laboratory II	.....	.....	0-3-1
ME 3213 Mechanical Behavior of Materials	.....	3-0-3	.....
ME 3056 Experimental Methodology	.....	.....	2-3-3
ME 3113 Kinematics and Dynamics of Linkages	3-0-3	.....	.....
ME 3114 Dynamics of Machinery	.....	3-0-3	.....
ME 3180 Mechanical Engineering Design I	.....	.....	3-0-3
ENGL 3020 Technical Writing	.....	3-0-3	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	.....	3-0-3
Mathematics Elective	.....	.....	3-0-3
TOTALS	17-6-19	17-0-17	16-6-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 4421 Senior Electrical Engineering Laboratory II	0-3-1	.....	.....
ME 4054 Thermal Sciences Laboratory	2-3-3	.....	.....
ME 4180 Mechanical Engineering Design II	3-0-3	.....	.....
ME 4182 Mechanical Design Engineering or ME 4317 Thermal Systems Design	.....	.....	1-6-3
ME 4055 Experimental Engineering	.....	1-3-2	.....
ME 4445 Automatic Control	3-0-3	.....	.....
ISYE 4725 Engineering Economy	.....	3-0-3	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	6-0-6	3-0-3
Free Electives	.....	3-0-3	3-0-3
ME Design Elective	.....	.....	3-0-3
Technical Electives	3-0-3	3-0-3	6-0-6
TOTALS	14-6-16	16-3-17	16-6-18

ELECTIVES

Freshman Engineering Elective
Any of the following courses are acceptable for credit as freshman engineering electives: CHE 1110, CE 1503, EE 1010, 1011, ESM 1101, NE 1010, 1100, NS 1002, 1003, or TEX 1100.

Humanities/Social Sciences/Modern Languages Electives
For selection of acceptable Humanities and Social Sciences courses, see the list of electives allowed by the College of Engineering in "Information for Undergraduate Students," Humanities and Social Sciences Requirements, pp. 41-42. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives
The free electives may be taken at any time during the course of study. If ROTC is elected by the student, six credit hours of free electives may be applied for basic and three hours for advanced ROTC courses.

Mathematics Elective
The list of acceptable math electives is available in the mechanical engineering office

ME Design Elective
A list of acceptable ME design electives is available in the mechanical engineering office.

Technical Electives
Technical electives must be chosen from the list of acceptable electives in the mechanical engineering office. This list includes all 3000- and 4000-level ME courses as well as selected courses in other fields. Mechanical engineering courses at the 6000 level may also be scheduled provided the student has a grade point average of 3.0 or higher and prior consent is obtained from both the instructor and the associate director for Graduate Studies.

A student completing his or her junior year with a grade point average of 2.5 or higher may elect one technical elective from the special problem courses, 4901 through 4904.

Six hours of advanced ROTC courses may be used for technical elective credit by students in the ROTC program.

Nuclear Engineering and Health Physics Programs

Nuclear engineering is the branch of engineering directly concerned with the release, control, utilization, and environmental impact of energy from nuclear fission and fusion sources. Today, the diversity of nuclear energy allows a wide variety of applica-tions, from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the need for nuclear power to produce the large amount of energy demanded by our society becomes more pressing. Programs in nuclear engineering are playing an important role in educating the technical manpower required to meet this need.

Health physics is an applied science concerned with the protection of people and the environment from the hazards of radiation and chemical pollutants. Health physicists develop a sound philosophy of radiation protection, apply these principles on the job in an industrial or medical setting or with a regulatory agency, and devise new methods and instrumentation for the protection of both individual workers and the general public.

Undergraduate Programs
The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment immediately after graduation and the student planning to pursue graduate study. It provides maximum flexibility in the form of options for each student to develop his or her unique interests and capabilities. The core curriculum covers the basic principles of nuclear engineering:

nuclear reactor core design, nuclear fuel design, reactor systems engineering, nuclear fuel process engineering, nuclear power economics, and reactor operations.

Study for the bachelor's degree in health physics may lead to a career in radiation protection, environmental surveillance, or medical physics or may prepare the student for further study at the graduate level and eventually for a professional career as a health physicist. The program also provides an excellent premedical education.

In addition to the Institute's academic requirements for graduation with a bachelor's degree, the average aggregate grade point ratio in nuclear engineering and health physics courses taken toward the B.N.E. degree or B.S.H.P. degree shall be 2.0 or higher. Further, for students in the B.N.E. program, the average aggregate grade point ratio for courses taken in engineering thermodynamics and transport phenomena shall be 2.0 or higher. Students must pass all required mathematics courses with a grade of C or higher. Only the highest grade received in any repeated course will be used in calculating quality points for these supplemental criteria.

Graduate Program
Graduate programs in nuclear engineering and health physics lead to the degrees Master of Science in Nuclear Engineering, Master of Science, Master of Science in Health Physics, and Doctor of Philosophy.

The master's program in nuclear engineering includes options in either reactor engineering or fusion. Within these areas, students may specialize further by constructing curricula from various combinations of nuclear engineering courses supplemented with courses in other schools. The program in health physics also has several different areas of specialization emphasizing power plant health physics or medical physics.

In nuclear engineering, students with a Bachelor of Science in Engineering pursue the Master of Science in Nuclear Engineering while students with a Bachelor of Science enroll for the Master of Science. Students graduating in health physics receive the Master of Science in Health Physics.

Depending on the career objectives of the student, the School may encourage a thesis as part of the Master of Science program. When appropriate, students may substitute approved courses and research experience or a special problem for a thesis.

The doctoral program is designed with great latitude to capitalize on variations in experience and interests of individual students. The School encourages its students to enroll not only in nuclear engineering courses but also in courses related to their subject areas offered by other schools.

Multidisciplinary Programs.
See table on page 83.

Facilities
The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include a 5-megawatt research reactor, a subcritical assembly, 1,000,000 curie cobalt-60 sources, several small digital computers, CDC CYBER 170/835, 170/855, and 170/990 computers, IBM 4341 and VAX 11/750, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, nuclear radiography equipment, radiochemical laboratories, and facilities for analyzing environmental samples by nuclear techniques.

Bachelor of Nuclear Engineering Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
NE 1100 Energy and Engineers in Society or			
Freshman Engineering Elective	X-X-3	.....	.....
EGR 1170 Visual Communication and Engineering Design	.....	2-3-3	.....

Course	1st Q.	2nd Q.	3rd Q.
NE 1010 Computer Programming for Nuclear Engineers	.....	.....	2-3-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	X-X-3	.....
TOTALS	X-X-16	X-X-19	14-6-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 2309 Differential Equations	.....	.....	5-0-5
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics	.....	3-0-3	.....
ESM 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
Humanities/Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Electives	2-0-2	3-0-3	3-0-3
Totals	17-3-18	18-3-19	16-0-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 3001 Modern and Nuclear Physics	5-0-5	.....	.....
NE 3110 Nuclear Radiation Detection	.....	.....	2-6-4
NE 3211 Elements of Nuclear Engineering	3-0-3	.....	.....
NE 4201-2 Nuclear Reactor Physics I and II	.....	3-0-3	3-0-3
HP 4412 Principles of Health Physics	.....	3-0-3	.....

Course	1st Q.	2nd Q.	3rd Q.
MATH 4582 Advanced Engineering Mathematics	3-0-3	.....	.....
MATH 4581 Advanced Engineering Mathematics	.....	.....	3-0-3
ME 3322-3 Thermodynamics	3-0-3	3-0-3	.....
ME 3340 Fluid Mechanics I	.....	3-0-3	.....
ME 3345 Conduction and Radiation Heat Transfer	.....	.....	3-0-3
EE 3701 Electric Circuits	2-0-2	.....	.....
EE 3400 Instrumental Laboratory	.....	1-3-2	.....
Humanities/Social Sciences Electives	3-0-3	3-0-3	3-0-3
TOTALS	19-0-19	16-3-17	14-6-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
NE 4211-2 Reactor Engineering I, II	3-0-3	3-0-3	.....
NE 4205 Reactor Laboratory	1-6-3	.....	.....
NE 4260 Radiation Transport and Shielding	.....	3-0-3	.....
NE 4231-2 Nuclear Engineering Design Theory, Applications	.....	1-0-1	0-9-3
NE 4011-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
MET 4403 Introductory Nuclear Metallurgy	.....	3-3-4	.....
ISYE 4725 Engineering Economy	3-0-3	.....	.....
Humanities/Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Elective	.....	.....	3-0-3
Technical Electives	3-0-3	3-0-3	6-0-6
TOTALS	14-6-16	17-3-18	13-9-16

SUBSTITUTIONS
Any of the courses listed under Freshman Engineering Electives in the College of Engineering section of Curricula and Courses of Instruction, with the exception of

EE 1010 and NE 1010, are acceptable substitutes for NE 1100: CHE 1110, CE 1503, EE 1011, ESM 1101, NS 1002, 1003 or TEX 1100.

A list of courses that may be substituted for required courses NE 1010, MATH 4581, and MET 4403 is available in the office of the nuclear engineering and health physics programs.

ELECTIVES
Humanities/Social Sciences/Modern Languages Electives
See Humanities and Social Sciences Requirements in "Information for Undergraduate Students," pp. 41-42, for a list of acceptable courses. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Technical Electives
Technical electives are chosen by students after consultation with their advisers. A list of acceptable electives is available in the office of the Nuclear Engineering and Health Physics Programs.

Those students in ROTC may use a maximum of six credit hours of basic ROTC and five credit hours of advanced ROTC as free electives. An additional four credit hours of advanced ROTC may be applied to the technical elective requirement.

Bachelor of Science in Health Physics Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Freshman Engineering Elective	X-X-3	.....	.....
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	X-X-3	.....
Free Elective	.....	.....	3-0-3
TOTALS	X-X-16	X-X-16	15-3-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	.....	.....
PHYS 2123 Optics and Modern Physics	.....	4-3-5	.....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 2309 Ordinary Differential Equations	.....	.....	5-0-5
BIOL 1110-1 Principles of Biology	3-3-4	3-3-4	.....
NE 1010 Computer Programming for Nuclear Engineers	.....	.....	2-3-3
HP 2401-2-3 Introduction to Health Physics	1-0-1	1-0-1	1-0-1
Free Electives	.....	.....	6-0-6
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
TOTALS	16-6-18	16-6-18	17-3-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 3001 Introduction to Modern Physics	5-0-5	.....	.....
PHYS 3211 Electronics	.....	5-6-7	.....
NE 3110 Nuclear Radiation Detection	.....	.....	2-6-4
HP 4410-2-3 Radiation and Health Physics	3-0-3	3-0-3	3-3-4
MATH 4582 Advanced Engineering Mathematics	3-0-3	.....	.....
BIOL 4415 Introduction to Radiation Biology	.....	3-3-4	.....
Probability/Statistics Elective	3-0-3	.....	.....

Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Technical Elective	.....	.....	3-0-3
Biology Elective	.....	.....	3-0-3
TOTALS	17-0-17	14-9-17	14-9-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
NE 4011-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
CHEM 4701 Chemistry of Nuclear Technology	.....	3-3-4	.....
NE 4260 Radiation Shielding	.....	3-0-3	.....
HP 4401-2-3 Health Physics Seminar	1-0-1	1-0-1	1-0-1
NE 3211 Elements of Nuclear Engineering	3-0-3	.....	.....
HP 4903 Special Problems in Health Physics	.....	.....	0-9-3
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Electives	3-0-3	3-0-3	3-0-3
Technical Electives	3-0-3	.....	3-0-3
TOTALS	14-0-14	14-3-15	11-9-14

ELECTIVES
Freshman Engineering Electives
Any of the following courses are acceptable for credit as freshman engineering electives: CHE 1110, CE 1503, EE 1011, ESM 1101, NE 1100, NS 1002, 1003, or TEX 1100.

Humanities/Social Sciences/Modern Languages Electives
See Humanities and Social Sciences requirements in "Information for Undergraduate Students," pp. 41-42. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives
If ROTC is elected by the student, a maximum of six credit hours of basic ROTC and nine credit hours of advanced ROTC may be counted as free elective hours.

Probability/Statistics Elective
Courses in probability, statistics, and data analysis may be selected by the student after consulting with his or her adviser. A list of these courses is available in the office of the Nuclear Engineering and Health Physics Programs.

Technical Electives
Technical electives will be selected by the student after consultation with his or her adviser.

Biology Elective
A list of acceptable biology electives is available in the office of the Nuclear Engineering and Health Physics Programs.

Courses of Instruction
MECHANICAL ENGINEERING

ME 2016. Computer Applications
2-3-3. Corequisites: MATH 3308, PHYS 2123, and knowledge of FORTRAN.
Organization and application of digital computers. Application of numerical methods to the solution of mechanical engineering problems. Problem analysis, solution techniques, computer program organization, and error analysis are included.

ME 3056. Experimental Methodology
2-3-3. Prerequisites: MATH 3308 and ME 3322.
Presentation of experimental methodology and basic instrumentation used in mechanical engineering and its calibration and use, accuracy, error, and uncertainty in experimental measurements.

ME 3110. Creative Decisions and Design
2-3-3. Prerequisite: junior or senior standing.
Basic concepts for creative decisions in engineering problem solving and design. Exposure to practicing engineers, their industries, and design problems.

ME 3113. Kinematics and Dynamics of Linkages
3-0-3. Prerequisite: ESM 3201.
Kinematics and dynamics of linkages with emphasis on inertial forces. Balancing of rotating and reciprocating systems.

ME 3114. Dynamics of Machinery
3-0-3. Prerequisites: ME 3113, MATH 3308.
Dynamic modeling of systems with mechanical, fluid, thermal, and/or electrical elements. Analysis including linearization, transient and frequency response, and stability. Vibration of mechanical systems.

ME 3180. Mechanical Engineering Design I
3-0-3. Prerequisites: ESM 3301, ME 3213.
The design process, including creativity and the use of statistical methods. Fundamentals of integrating properties

and failure theories into designing for static and fluctuating loads.

ME 3183. Rational Descriptions and Engineering Design
3-0-3. Prerequisite: junior standing in engineering.
Information-theory decision analysis for engineering design, with practical applications to the design of mechanical, thermal, and electrical components and systems.

ME 3213. Mechanical Behavior of Materials
3-0-3. Prerequisites: ESM 3301, MET 3301.
Strengthening by phase transformation. Mechanical behavior and properties of metallic and nonmetallic materials, including creep, fatigue, fracture, and stress-strain response.

ME 3322. Thermodynamics I
3-0-3. Prerequisites or corequisites: PHYS 2123, MATH 2308.
An introduction to thermodynamics. Thermodynamic properties, state postulate, work interactions, steady state and transient energy and mass conservation, entropy and the second law.

ME 3323. Thermodynamics II
3-0-3. Prerequisite: ME 3322. Corequisite: MATH 3308.
Continuation of ME 3322. Second-law analysis of thermodynamic systems, gas cycles, vapor cycles, thermodynamic relationships.

ME 3324. Thermodynamics III
3-0-3. Prerequisites: ME 3322, 3323.
Continuation of ME 3323. Thermodynamic behavior of real gases, nonreacting gas mixtures, first- and second-law analysis of chemical reactions, chemical equilibrium.

ME 3340. Fluid Mechanics I
3-0-3. Prerequisites: ESM 3201, 3301, MATH 3308. Pre- or corequisite: ME 3322.
Introduction to fluid mechanics, fluid statics, integral and differential control volume analyses with applications, study of similitude, simple laminar flows.

ME 3345. Conduction and Radiation Heat Transfer
3-0-3. Prerequisite: MATH 3308. Pre- or corequisite: ME 3322.
Introduction to the study of heat transfer, transport coefficients, steady state conduction, transient conduction, radiative heat transfer.

ME 3347. Fluid Flow and Convection
3-0-3. Prerequisites: ME 3340, 3345.
Transition and turbulence in fluid flow, laminar and turbulent boundary layers, forced and natural convection, one-dimensional compressible flow.

ME 3720. Thermodynamics
4-0-4. Pre- or corequisite: MATH 2308. Not for ME students.
Fundamentals of engineering thermodynamics, thermodynamic properties of matter, the concept of conservation of energy, the second law of thermodynamics and application to engineering processes.

ME 4025. Engineering Analysis
3-0-3. Prerequisite: consent of the School.
Emphasis is placed on well-ordered analytical thought processes required in the application of fundamental principles of engineering sciences to the analysis of unfamiliar engineering situations.

ME 4041. Interactive Computer Graphics and Computer-aided Design
2-3-3. Prerequisites: ME 2016, senior standing.
Principles of interactive computer graphics hardware and software. Programming for interactive graphics with application to the solution of thermal and mechanical design problems. Design projects.

ME 4054. Thermal Sciences Laboratory
2-3-3. Prerequisites: ME 3056, 3323, 3347.
Observation, measurement, and analysis of basic thermodynamic, fluid, and heat transfer phenomena. Special emphasis on the computer as a laboratory tool for data acquisition, reduction, analysis, and report preparation.

ME 4055. Experimental Engineering
1-3-2. Prerequisites: ME 3056 and ME senior standing.
Engineering situations involving various disciplines are solved by experimental means. Students must plan experimental approach, gather data, interpret results, and prepare a formal engineering report.

ME 4091. Seminar
1-0-1. Prerequisite: ME senior standing. Fall quarter only.
Civic and professional responsibilities and opportunities are brought to students by leaders in engineering, business, and community affairs.

ME 4180. Mechanical Engineering Design II
3-0-3. Prerequisite: ME 3180.
Application of the design process in the creation and selection of mechanical systems. Fasteners, welding, springs, bearings, shafts, gears, and other elements are utilized.

ME 4182. Mechanical Design Engineering
1-6-3. Prerequisites: ME 4180 and ME senior standing.
The design process is applied to real multidisciplinary problems by a team. Problems selected from a broad spectrum of interest areas, including biomedical, ecological, environmental.

ME 4186. Biomechanical Design
3-3-4. Prerequisite: ME 4445 or equivalent.
Design of systems utilizing human operator dynamics in the loop. Biological systems treated as structures, power sources and information systems, operator modeling.

ME 4187. Kinematic Design
2-3-3. Prerequisite: ME 3113 or consent of the School.
The design of mechanisms to generate specified point paths or analytical functions. Graphic and analytic design methods are shown.

ME 4188. Cams and Gears
3-0-3. Prerequisite: ME 3113 or equivalent.
Selection and design of gears, spur, bevel, helical, and worm gearings are treated. Cam design with applications including high-speed systems.

ME 4189. Structural Vibrations
3-0-3. Prerequisites: ME 2016, 3113, 3114.
Single and multidegree-of-freedom systems as well as simple continuous systems are analyzed for their vibrational response characteristics using both exact and approximate methods.

ME 4205. Manufacturing Processing: Casting and Joining
2-3-3. Prerequisites: ME 4212, ESM 3301.
An intermediate level treatment of two important manufacturing operations, emphasis on the engineering and technological aspects of these processes, applications and design criteria.

ME 4212. Material Processes
3-3-4. Prerequisites: ME 3213 and senior standing. Consent of the instructor for non-ME students.
Fundamentals of various techniques for solidification, working, and shaping materials. Machining, casting, joining, and metal forming are major topics. Laboratory practice supplements classroom treatment.

ME 4265. Materials Science and Engineering
3-0-3. Prerequisite: ME 3213.
Advanced studies of metals, polymers, ceramics. Atomic and molecular structure, crystal binding, defects, relationship of properties to microstructures. Phase equilibria, strengthening, failure, steel constituents, hardenability.

ME 4316. Thermal Systems Analysis
3-0-3. Prerequisites: ME 3323, 3347.
The application of the principles of thermodynamics and transport phenomena to the analysis of thermal systems and components, with examples from areas such as power generation, refrigeration, and propulsion. Computer simulation.

ME 4317. Thermal Systems Design
1-6-3. Prerequisites: ME 3323, 4180, and ISYE 4725.
Design and optimization of thermal systems and components, with examples from areas such as power generation, refrigeration, and propulsion.

ME 4319. Thermoeconomic Design
3-0-3. Prerequisites: ME 3323, 3347, 4180.
Design via synthesis and optimization of systems, components, and subcomponents modeled from thermal phenomena or their direct analogs while considering constraints from cost, size, weight, government regulations, and other such factors.

ME 4321. Principles of Air Conditioning
3-3-4. Prerequisite: ME 3323, 3347, or consent of the School.
Psychrometric principles. Thermal comfort. Loan estimates. Environmental control. System design using loan wedge and supply area concepts. Experiments to determine components and system performance.

ME 4323. Internal Combustion Engines
3-0-3. Prerequisites: ME 3323, 3347.
Principles, practice, and characteristics of internal combustion engines, with laboratory demonstrations in engine testing and performance.

ME 4324. Power Plant Engineering
3-0-3. Prerequisite: ME 3323, 3347, or consent of the School.
Steam and gas turbine power cycles. Modern power plants. Combined power plants. Energy and availability analysis. Economics of power generation. Design problems and field trips.

ME 4326. Principles of Turbomachinery
3-0-3. Prerequisite: ME 3347 or consent of the School.
Head, flow, and power relationships for turbomachines and their systems. Design of impellers and casings for various types of compressors, turbines, and pumps.

ME 4327. Combustion and Flames
3-0-3. Prerequisite: ME 3324, 3347, or equivalent.
Stoichiometric and thermochemical analysis of fuel-oxidant reactions. Heat and mass transfer with chemical reaction applied to combustion of gas jets, solid and liquid fuels.

ME 4329. One-dimensional Compressible Flow
3-0-3. Prerequisites: ME 3347, 3323.
Fundamentals of one-dimensional steady and unsteady compressible flows. Isentropic flows, flows with friction and heat transfer and with shocks are examined.

ME 4331. Refrigeration
3-0-3. Prerequisite: ME 3323.
Refrigeration cycles and systems. Balanced design concepts in selecting components. System performance at off-design conditions. Heat pumps.

ME 4339. Gas Turbines
3-0-3. Prerequisites: ME 3323, 3347.
Applications of gas turbines, including limitations and advantages as compared with other prime movers. Design of compressor, combustor, and turbine components.

ME 4343. Heating, Ventilating, and Air-conditioning Design
3-0-3. Prerequisite: ME 4321.
Sizing of equipment for environmental control. Design of transportation and delivery systems. Energy recovery schemes. Total energy concepts and design features.

ME 4357. Plasmas and Engineering Applications
3-0-3. Prerequisites: ME 3323 and senior standing.
Occurrence of plasmas, review of electromagnetic theory, thermodynamics of ionized gases, equations of magnet hydrodynamics, MHD waves, channel flow, application to electric arcs, MHD energy conversion and fusion.

ME 4367. Solar Utilization Systems
3-0-3. Prerequisite: ME 3323 or ME 3720 with consent of the School.
Solar energy resources, collector models, active DHW and space heating systems, passive heating. Utilizability and design-chart methods. Introduction to cooling, photovoltaic, wind, and OTEC systems. Design projects.

ME 4445. Automatic Control
3-0-3. Prerequisites: ME 2016, 3114.
Analysis and modeling of linear systems and compensation of feedback controlled systems using classical methods. Hydraulic, pneumatic, thermal, electrical, nuclear, chemical, and biomechanical examples.

ME 4447. Microprocessors in Mechanical Systems
2-3-3. Prerequisites: EE 3702, EE 3703, ME 3056.
Design at the chip level and assembly language programming for measurement and control. Hands-on

experience interfacing sensors and actuators with micro-processors and microcomputers.

ME 4449. Numerical Control of Machine Tools
3-0-3. Pre- or corequisite: ME 4445.
Study of design and operation of typical digital control systems for machine tools, including the flow of signals through the system.

ME 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.
Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound fields in large and small rooms, noise legislation.

ME 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: ME 4761 or equivalent.
Continuation of ME 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping.

ME 4771. Pulp and Paper Processes I
3-0-3. Prerequisite: consent of the School.
A survey of the processes in a kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, wood chemistry and morphology. The chemical and mechanical characteristics of kraft pulping and chemical recovery processes. Cross-listed with CHE.
Text: Britt, *Handbook of Pulp and Paper Technology.*

ME 4772. Pulp and Paper Processes II
3-0-3. Prerequisite: consent of the School.
The major pulping processes other than kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleaching process. Cross-listed with CHE.
Text: Britt, *Handbook of Pulp and Paper Technology.*

ME 4773. Paper Formation and Properties
3-0-3. Prerequisite: consent of the School.
The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Cross-listed with CHE and TEX.
Text: Britt, *Handbook of Pulp and Paper Technology.*

ME 4780. Energy Conversion Engineering
3-0-3. Prerequisite: ME 3720 or equivalent.
Energy sources, basic principles of semiconductors, thermoelectric converters, solar power, thermionic systems, MHD, applications of these devices for power generation, environmental effects, cost factors.

ME 4801-2-3-4-5. Special Topics, Mechanical Engineering
1-0-1 to 5-0-5, respectively.
Special topic offerings of current interest not included in regular courses.

ME 4901. Special Problems, Mechanical Engineering
Credit to be arranged.
Individual studies in certain specialized areas, and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

ME 6014. Engineering Instrumentation
3-3-4. Prerequisite: ME 3056 or equivalent or graduate standing.
Methods and techniques of modem instrumentation in engineering research. Emphasis on analytical methods in planning and evaluation of experiments, integration of experimentation theory with practical aspects of instrumentation problems.

ME 6024-5. Variational Methods in Engineering I, II
3-0-3 each. Prerequisite: ME 3347, ESM 3302, or equivalent.
Variational methods applied to the optimization of engineering systems, the formulation and approximate solution of differential equations with application to nonlinear vibration, fluid mechanics, heat transfer, hydro-dynamic stability, and automatic control.

ME 6121. Advanced Dynamics of Machinery
3-0-3. Prerequisite: consent of the School.
Design-oriented dynamics. Dynamics of systems with constraints, application of virtual work-minimum potential to systems, dynamical equations of Lagrange, Hamilton.

ME 6122. Machine Vibration
3-0-3. Prerequisite: consent of the School.
Application of dynamic theory to practical situations, natural frequencies of systems, impact, impulse and momentum, discrete and continuous system techniques, periodic and random sources.

ME 6125. Mechanism Synthesis I
3-0-3. Prerequisite: ME 4187 or equivalent.
A continuation of ME 4187. Advanced topics in curvature theory. Finite displacement of a plane, Burmester theory. Current developments in kinematics. Graphic nd analytic design methods.

ME 6133. Elastic Yield Design of Machine Members
3-0-3. Prerequisite: consent of the School.
The methods of strain-energy, virtual work, area-moment, and Castigliano's theorem are applied to the design of machine members against excessive deformation.

ME 6170. Engineering Design
3-6-5. Prerequisite: consent of the School.
Design concepts, life design, fatigue and failure, thermal stress, and the elements of optimum design are studied.

ME 6175. Fundamentals of Computer-aided Design
3-0-3. Prerequisites: graduate standing, ME 2016, 4180, and 4445 or equivalent.
Introduction to the use of interactive computing techniques of engineering design, with emphasis on interactive graphics and man-machine interaction.

ME 6176. Computer-aided Design Systems— Components and Techniques
3-0-3. Prerequisite: ME 6175 or consent of the instructor.
An in-depth study of necessary hardware and software for development of computer-aided design systems, with special emphasis on man-machine interface.

ME 6239. Materials for Design
3-0-3. Prerequisite: ME 4212.

Properties, behavior, and selection of materials for practical design applications. Topics include the behavior of metals, ceramics, polymers, composites, and the design process.

ME 6271. Deformation of Metals
3-0-3. Prerequisite: ME 4212.
Advanced study of atomic structure and imperfections in crystalline solids. Topics include plastic deformation, strain hardening, annealing processes, creep, fatigue, ductile and brittle fracture.

ME 6272-3. Fabrication of Metals I, II
3-0-3 each. Prerequisite: ME 6271.
Fabrication processes of metals including forging, rolling, extrusion, drawing, deep drawing, and pressing. Frictional phenomena, slip line fields, upper bound forces, material properties, and characteristics.

ME 6322. Thermodynamics I
3-0-3. Prerequisite: undergraduate thermodynamics.
Thorough study of the principles of macroscopic formalism of thermodynamics. Thermodynamic systems, pure substance, multi-phase mixtures, reactive systems.

ME 6323. Thermodynamics II
3-0-3. Prerequisite: undergraduate thermodynamics.
Microscopic thermodynamics based on classical mechanics, quantum mechanics, and information theory. Prediction of macroscopic properties and system behavior from statistical considerations.

ME 6324. Thermodynamics III
3-0-3. Prerequisite: ME 6323 or equivalent.
Statistical thermodynamic calculation of properties of ideal gases, real gases, solids, and gas mixtures. Kinetic theory and transport properties. Thermodynamics of special systems.

ME 6325. Information Theory Thermodynamics
3-0-3. Prerequisite: ME 6323 or consent of the School.
A derivation from information theory of the fundamentals of thermodynamics and statistical mechanics. Applications to irreversible thermodynamics and the design of thermosystems.

ME 6332. Heat Transfer I
3-0-3. Prerequisite: ME 3347 or consent of the School.
Conduction (steady state and transient), one- and multidimensional parentheses geometries. Emphasis on analytical methods, exact and approximate, and numerical techniques.

ME 6333. Heat Transfer II
3-0-3. Prerequisite: ME 6332 or consent of the School.
Convection (forced and free) in laminar and turbulent, internal parentheses and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

ME 6334. Heat Transfer III
3-0-3. Prerequisite: graduate standing.
Radiation-electrodynamics, radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through continua, experimental methods.

ME 6342. Fluid Flow I
3-0-3. Prerequisite: ME 3340 or consent of the School.

A general development of the continuity, linear and angular momentum and energy equations followed by the fundamentals of perfect fluid theory.

ME 6343. Fluid Flow II
3-0-3. Prerequisite: ME 6342 or equivalent.
Viscous flow theory, including derivation of Navier-Stokes equations, a study of their general properties and their applications to creeping flow and to laminar and turbulent boundary layers.

ME 6344. Fluid Flow III
3-0-3. Prerequisite: ME 6343 or equivalent.
Turbulent flow theory, origins of turbulence, turbulent stress, mixing-length models, free turbulent flow, flow in pipes and boundary layers, statistical description of turbulence.

ME 6351. Direct Energy Conversion
3-0-3. Prerequisite: ME 3720 or equivalent.
Analysis of performance characteristics, based on thermodynamic and fluid flow principles, of direct energy conversion devices such as thermionic, thermoelectrics, photovoltaic, magnetohydrodynamic, electrohydro-dynamic generators, and fuel cells.

ME 6352. Energy Conversion Systems
3-0-3. Prerequisite: ME 3323 or equivalent.
A study of alternative energy conversion systems and analysis of their economic and commercial performance characteristics.
Comparative analysis of Otto, Diesel, Brayton, Rankine, solar and direct energy conversion systems.

ME 6353. Diagnostics of Combustion Gases and Plasmas
3-0-3. Prerequisite: statistical thermodynamics.
Study of diagnostic techniques for combustion gases and plasmas. Review of relevant physical phenomena. Spectroscopic, interferometric, laser, and probe techniques. Treatment includes latest techniques and procedures.

ME 6355. Combustion I
3-0-3. Prerequisite: graduate standing.
Conservation laws and constitutive equations in reactive media. Reactions kinetics, laminar and turbulent diffusion flames.

ME 6356. Combustion II
3-0-3. Prerequisite: ME 6355 or equivalent.
Combustion of liquid and solid fuels. Combustion in laminar boundary layers.

ME 6370. Thermal Environmental Control
3-0-3. Prerequisite: consent of the School.
Thermodynamic relations of moist air. Air-conditioning processes. Environmental systems for thermal comfort. Direct and indirect contact transport processes.

ME 6371. Advanced Refrigeration
3-0-3. Prerequisite: consent of the School.
Development of design and performance characteristics of vapor compression, absorption, and several other work and heat input refrigeration cycles. Specification of desirable refrigerant properties.

ME 6376. Internal Combustion Engine Design
3-0-3. Prerequisite: undergraduate design, ME 4324, or equivalent.

Internal combustion engine design practice to accommodate challenges of application, efficiency, emissions, and balance.

ME 6379. Turbines
3-0-3. Prerequisite: ME 4339, 4326, or consent of the School.
Basic fluid mechanics and thermodynamics of the expansion processes in various types of radial and axial flow turbines. Current literature is discussed.

ME 6383. Lubrication
3-0-3. Prerequisite: consent of the School.
Hydrodynamic, hydrostatic, liquid and gas lubrication, elastohydrodynamic lubrication, lubricant properties, boundary lubrication, friction and solid lubricants are covered from fundamental development through design considerations.

ME 6424. Feedback Control Systems I
3-0-3. Prerequisite: ME 4445 or equivalent.
Linear systems. Integration of classical (root locus, frequency response) and modern (state feedback, observers) techniques. Mechanical, thermal, fluid, chemical, and nuclear examples.

ME 6425. Feedback Control Systems II
3-0-3. Prerequisite: ME 6424 or equivalent.
Discrete time and nonlinear systems. Sampled data and digital control. Phase plane, describing functions and Lyapunov methods.

ME 6426. Feedback Control Systems III
3-0-3. Prerequisite: ME 6424 or equivalent.
Optimal systems. Maximum principle and dynamic programming. Quadratic linear optimization. Kalman filtering. Computational methods.

ME 6437-8. Digital Control Systems I and II
3-0-3, 3-3-4. Prerequisite: graduate standing or consent of the School. ME 6437 is prerequisite for 6438.
The basic theory and techniques employed in the design of control systems for numerically controlled machine tool and digital computers.

ME 6439. Control System Components
2-1-3. Prerequisite: ME 4445 or equivalent.
The performance characteristics and the mathematical modeling of control system components, particularly microprocessors, sensors, actuators, and analog devices of modem systems.

ME 6751. Complex Systems Design
2-4-3. Prerequisite: graduate standing in any school or senior standing with consent of the School.
Interdisciplinary team design of systems of current interest to society that have large technological factors. Individual research and interaction with non-Institute resource persons and non-Institute faculty. Grades based on oral and written reports. Cross-listed with ESM, ISYE.

ME 6755. Polymer Structure and Mechanical Properties
3-0-3. Prerequisite: CHE 4751 or TEX 4751.
Fundamental aspects of the development and analysis of structure, and molecular and phenomenological models of mechanical behavior of solid-like polymers are presented. Cross-listed with TEX 6765 and CHE 6765.

ME 6756. Mechanical Properties of Polymers
3-0-3. Prerequisite: CHE 4751 or TEX 4751.
Mechanics of deformation of anisotropic polymers; anisotropy and critical phenomena, such as yield, breaking, and fatigue, in the mechanical behavior of polymers; engineering applications. Cross-listed with TEX 6766 and CHE 6766.

ME 6760-1. Acoustics I and II
3-0-3 each. Prerequisite: partial differential equations or consent of the School.
Governing equations of sound waves from the conservation laws. Acoustic momentum, energy, and intensity. Propagation, reflection, absorption, and scattering. Effects of the physical properties. Application of the theory of sound to real systems. Transmission of sound in real media.

ME 6762. Acoustics III
3-0-3. Prerequisite: ME 6761.
Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics.

ME 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisite: ME/AE/ESM 6760, ME 4025 or equivalent.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction, and damping methods.

ME 6764. Ocean Acoustics
3-0-3. Prerequisite: GEOS 4300 or consent of the School. MATH 4321, 4582, ESM 6760 recommended.
Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Cross-listed with GEOS, ESM.

ME 7000. Master's Thesis

ME 7035. Numerical Methods in Mechanical Engineering
3-0-3. Prerequisite: graduate standing.
Numerical analysis of deterministic engineering systems. Numerical approximations to mathematical operations. Initial and boundary value problems. Computational stability for ordinary and linear partial differential equations.

ME 7122. Advanced Machine Vibrations
3-0-3. Prerequisite: ME 6122 or consent of the School.
Applications of vibration theory. Machinery response on resilient mounting. Kinematic and dynamic stability. Nonlinear systems in electromechanical and mechanical design.

ME 7140. Decision Theory for Engineering Design
3-0-3. Prerequisite: MATH 4215 or consent of the School.
Use of information-theory decision analysis in solving practical problems in engineering design and reliability that cannot be effectively treated by any other method.

ME 7222-3. Fracture and Fatigue of Material I, II
3-0-3 each. Prerequisite: ME 6271.
Advanced study of failure of structural materials under load. Mechanics of fracture, microscopic and macroscopic aspects, fracture of specific materials; steels, nonferrous alloys, nonmetallic materials.

ME 7322. Thermodynamics of Irreversible Processes I
3-0-3. Prerequisite: graduate standing.
Principles and formalism of thermodynamics of near-equilibrium states. Phenomenological equations and the Onsager-Casimir reciprocal relations. Coupled linear processes and cross-effects.

ME 7338. Advanced Topics in Heat Transfer
3-0-3. Prerequisites: ME 6332, 6333, 6334.
Latest advances in heat transfer, boiling, and two-phase flows, liquid metal heat transfer, influence of main stream turbulence, separated flows, porous media, radiation and conduction.

ME 7341. Transport Phenomena in Two-phase Flow
3-0-3. Prerequisite: consent of the School.
Dispersed and separated flows—field and constitutive equations, jump conditions. Interfacial phenomena, nucleation. Two-fluid and drift models, similarity, criteria. Dynamics, propagation phenomena, kinematic waves.

ME 7999. Preparation for Doctoral Qualifying Exam
Audit only. Prerequisite: consent of the School.

ME 8010-1-2-3. Seminars in Mechanical Engineering
1-0-1. Prerequisite: graduate standing.
Seminars involving current research projects presented by graduate students, ME faculty, and invited industrial speakers.

ME 8039. Heat Transfer Seminar
1-0-1.
Two presentations by each student of current research activities: thesis work and special problems, presentation of thesis proposals. Attendance in curriculum-related seminars.

ME 8041-2-3-4-5. Fluid Mechanics Seminar
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of the School.
Advanced current topic in fluid mechanics and fluid engineering, including applications of interest to mechanical engineering.

ME 8101-2-3-4-5. Special Topics in Design
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of the School.
Special topic offerings of current interest not included in regular courses.

ME 8201-2-3-4-5. Special Topics in Materials
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of the School.
Special topic offerings of current interest not included in regular courses.

ME 8301-2-3-4-5. Special Topics in Energetics
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of the School.
Special topic offerings of current interest not included in regular courses.

ME 8401-2-3-4-5. Special Topics in Systems and Controls
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of the School.

Special topic offerings of current interest not included in regular courses.

ME 8501. Special Problems in Mechanical Engineering
Credit to be arranged. Prerequisite: consent of the School.
Individual studies in certain specialized areas and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

ME 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

ME 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

ME 8999. Preparation for Doctoral Dissertation
Audit only. Prerequisite: consent of the School.

ME 9000. Doctoral Thesis

NUCLEAR ENGINEERING

NE 1010. Computer Programming for Nuclear Engineers
3-0-3.
FORTRAN computer programming, graphics, and elementary numerical methods for NE freshmen will be taught using terminals to interact with the main computer on campus.

NE 1100. Energy and Engineers in Society
2-3-3.
Deals with the concept of energy, society's requirements, the sources of supply, power generation methods, and related environmental influences.

NE 3110. Nuclear Radiation Detection
2-6-4. Prerequisite: PHYS 3001.
A laboratory introduction to the principles and characteristics of basic detectors for nuclear radiations and the electronic systems associated with them.

NE 3211. Elements of Nuclear Engineering
3-0-3. Prerequisite: PHYS 2123. Corequisite: MATH 2309.
An introduction to the field of nuclear engineering. Topics include nuclear physics, reactor physics, heat removal, nuclear power systems, and reactor licensing, safety, and the environment.

NE 4011-2-3. Nuclear Engineering Seminar
1-0-1 each.
A regularly scheduled course required of NE seniors. Various topics presented by guest speakers, faculty members, and graduate students.

NE 4115. Nuclear Engineering Calculations with Digital Computers I
2-0-1.
Introduction to computer programming with emphasis on solution of problems relevant to nuclear engineering.

NE 4201. Nuclear Reactor Physics I
3-0-3. Prerequisites: PHYS 3001, NE 3211. Corequisite: MATH 4582.

The course covers the physical principles of nuclear reactors. Major topics include nuclear physics, neutron diffusion theory, criticality, and multigroup theory.

NE 4202. Nuclear Reactor Physics II
3-0-3. Prerequisite: NE 4201.

The course covers the physical principles of nuclear reactors. Topics include neutron moderation and thermalization, heterogeneity effects, reactor kinetics, and reactivity changes.

NE 4205. Reactor Laboratory
1-6-3. Prerequisite: NE 4202.

Students registering for NE 4205 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course.

Covers measurement methods of reactor parameters: approach to criticality, control rod calibrations, flux mapping, material reactivity coefficients, temperature coefficient, power calibration, activation analysis, cross sections measurement, and reactor checkouts and operations.

NE 4210. Reactor Operations
1-6-3. Prerequisites: senior standing and consent of the School.

Students registering for NE 4210 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course.

The course is designed to provide experience and knowledge of the reactor and its operation sufficient to satisfy the requirements of the USNRC to become an applicant for a Reactor Operators License.

NE 4211. Reactor Engineering I
3-0-3. Prerequisites: ME 3323 and 3340.

Engineering aspects of nuclear power plants. Thermodynamics of nuclear power systems. Single- and two-phase flow and pressure drop in reactors. Flow instabilities, critical flow, component performance.

NE 4212. Reactor Engineering II
3-0-3. Prerequisites: NE 4211 and ME 3345.

Continuation of NE 4211. Heat generation in nuclear power plants. Single- and two-phase heat transfer. Reactor thermal-hydraulic design and analysis. Stress analysis in reactor components.

NE 4231. Nuclear Engineering Design Theory
1-0-1. Prerequisites: NE 1010 and 4202. Corequisite: NE 4212.

An introduction to the methodologies of nuclear plant and systems design, with emphasis on the use of computer programs for nuclear-specific design aspects.

NE 4232. Nuclear Engineering Design Applications
0-9-3. Prerequisites: NE 4202, 4212, 4231.

A complete design project of a section of a nuclear power plant or of a nuclear fuel cycle facility.

NE 4260. Radiation Transport and Shielding
3-0-3. Corequisite: NE 4201 or equivalent.

NE 4260. Radiation Transport and Shielding
3-0-3. Corequisite: NE 4201 or equivalent.

Radiation transport and attenuation in homogeneous and heterogeneous bulk media. Emphasis on neutron and gamma-ray shielding. Shielding materials and shield design.

NE 4265. Light Water Reactor Technology
3-0-3. Prerequisites: NE 4202, 4212.

A systematic survey of the technology of both pressurized and boiling water reactors, with emphasis on the nuclear steam supply system and its associated safety and control systems.

NE 4301. Nuclear Fuel Cycle
3-0-3. Prerequisite: senior standing in science or engineering.

Systematic review of technologies used at fuel cycle facilities. Introduction to the economic, environmental, safety, and licensing aspects of the nuclear fuel industry.

NE 4610. Introduction to Fusion Power
3-0-3. Prerequisite: senior standing in science or engineering.

An introduction to magnetic confinement fusion. Topics include basic plasma physics, magnetic confinement concepts, fusion technology, and a review of the current status of fusion research.

NE 4720. Nuclear Technology and the Environment
3-0-3. Prerequisite: senior standing in science or engineering or consent of the School. No credit to NE or HP students.

Survey of technical and social aspects of nuclear technology ad their environmental and public health impacts and effects.

NE 4780. Energy Conversion Engineering
3-0-3. Prerequisite: ME 3720 or equivalent.

Energy sources, demand and supply; large electric generating systems (fossil, hydro, nuclear), energy storage, advanced generating systems (solar, geothermal, fusion) direct energy conversion (thermoelectric, thermionic, MHD, fuel cells).

NE 4801-2-3. Special Topics
3-0-3. Prerequisite: consent of the School.

The purpose of this course is to permit the Nuclear Engineering Program to offer formal courses on topics of special interest on an ad hoc basis.

NE 4901-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

Special engineering problems will be assigned to the student according to his or her needs and capabilities to foster individual effort and experience in research techniques.

NE 6101. Introduction to Nuclear Materials
3-0-3. Prerequisite: graduate standing.

Metallurgy and physical properties of uranium, ceramic fuels, cladding, structural, tritium breeding, and control materials. Properties of collants. Radiation damage effects.

NE 6102. Nuclear Fuel Elements
3-0-3. Prerequisite: NE 6101 or consent of the School.

Reactor fuel technology, including fuel preparation, assembly, and testing. In-core performance of fuel elements and fuel design procedures.

NE 6103. Nuclear Reactor Analysis I
3-0-3. Prerequisite: NE 4202 or equivalent.

Covers nuclear reactor physics at the graduate level. Topics include neutron reaction rates, neutron energy distribution, criticality, neutron diffusion theory, and neutron resonance absorption.

NE 6104. Nuclear Reactor Analysis II
3-0-3. Prerequisite: NE 6103.

Covers nuclear reactor physics at the graduate level. Topics include fuel depletion, nuclear reactor kinetics, neutron transport theory, multigroup diffusion theory, heterogeneous cores, and advanced topics.

NE 6110. Radiation Detection I
2-6-4. Prerequisite: PHYS 6011 or equivalent.

Introduction to measurement of radioactivity. Principles of radiation detection systems in common use. Application of radiation detectors for specific purposes.

NE 6111. Advanced Radiation Detection
3-0-3. Prerequisite: NE 6110 or equivalent.

Selected topics on modem radiation detection methods and fast pulse-circuit systems. Emphasis on neutron detection methods, scintillation detectors, and semiconductor devices.

NE 6113. Radiation Effects on Materials
3-0-3. Prerequisite: NE 6101 or equivalent.

Covers the effects of nuclear radiations on fuel and structural material in fission and fusion reactors. The heating effect of, and the chemical changes resulting from, nuclear radiations are also covered.

NE 6125. Nuclear Engineering Calculations with Digital Computers II
3-0-3. Prerequisite: NE 4115 or equivalent.

Introductory course on the use of numerical methods in solving diffusion/transport problems associated with neutronics, plasmas, radiation damage, and heat.

NE 6126. Monte Carlo Methods in Nuclear Engineering
3-0-3. Prerequisite: consent of the School.

Introductory course with application to radiation transport. Statistical background, generation and testing of pseudorandom numbers, random variables, applications to shielding and reactor physics, variance reduction methods.

NE 6140. Advanced Nuclear Fuel Cycle
3-0-3. Prerequisite: consent of the School.

Survey of the nuclear fuel cycle. Technologies of raw materials production, uranium conversion and enriching, fuel fabrication and reprocessing, waste management, economic and safety analyses.

NE 6201. Advanced Nuclear Reactor Physics I
3-0-3. Prerequisite: NE 6104.

Covers the transport equation and methods used to solve it. Specifically, the course covers derivation of the transport equation and its solution by integral, spherical harmonic, discrete ordinate, and Monte Carlo Methods.

NE 6202. Advanced Nuclear Reactor Physics II
3-0-3. Prerequisite: NE 6104.

Covers resonance self-shielding, adjoint transport equation, perturbation theory, variational techniques, thermalization of neutrons, and Dopplar broadening.

NE 6205. Nuclear Engineering Laboratory
1-6-3. Prerequisite: NE 6104.

Students registering for NE 6205 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course.

This course covers measurement of approach to criticality and reactivity coefficients, control rod calibration, activation analysis and reactor operation.

NE 6211. Nuclear Reactor Technology I
3-0-3. Prerequisite: consent of the school.

Design aspects of nuclear power plants. Thermodynamics of nuclear power systems. Single- and two-phase flow and pressure drop in reactors. Flow instabilities, critical flow, component performance. Heat generation in reactors. Single- and two-phase heat transfer. Stress analysis in reactor components. Intensive coverage for graduate students without a nuclear engineering background.

NE 6212. Nuclear Reactor Technology II
3-0-3. Prerequisite: NE 4212 or 6211.

Application of principles of reactor engineering to analysis of plant designs. Examples drawn from both fission and fusion technology.

NE 6220. Advanced Engineering Design
2-6-4. Prerequisites: NE 4202 and 4212 or 6212.

Course intended to give experience in the synthesis of principles of nuclear engineering in the design of nuclear reactors and other facilities.

NE 6229. Applied Reactor Theory
3-0-3. Prerequisite: NE 4202 or 6104.

The course covers the physical principles employed in computer codes used in the design of fast and thermal reactors. The codes will be used by the students to calculate design parameters.

NE 6230. Reactor Kinetics and Control
3-0-3. Prerequisite: NE 4202 or equivalent.

Covers the physical phenomena that govern the time dependence of the neutron population in a nuclear reactor and the methods used in their analysis. Topics include numerical methods, stability analysis, xenon oscillation, control theory, space-dependent kinetics, and noise analysis.

NE 6232. Nuclear Fuel Management
3-0-3. Prerequisite: NE 6251, 6760, or equivalent.

Nuclear fuel procurement options will be examined with regard to financing, scheduling, guarantees, risk, and cost. Calculational emphasis will be on in-core fuel management.

NE 6235. Nuclear Reactor Safety
3-0-3. Prerequisites: NE 4202 or equivalent and NE 4211 or 6211.

This course covers the physical mechanisms that can cause reactor transients and the methods used in their

analysis, the containment of accidents, and the quantitative methods of risk analysis.

NE 6237. Fast Reactor Physics and Technology
3-0-3. Prerequisite: NE 6104.
The course covers reactor physics and design topics of importance for fast breeder reactors.

NE 6260. Radiation Attenuation
3-3-4. Prerequisite: NE 6104.
Interaction of radiation with matter in bulk, absorption, scattering and attenuation of nuclear radiation, radiation transport theory, geometrical considerations, and transport solution methods.

NE 6601. Radioisotope Engineering I
3-0-3. Prerequisite: PHYS 6011 or equivalent.
Production and handling of radioisotope sources. Industrial and medical applications of tracer methods and radiation sources. Design procedures for radiation gauges and high-level irradiation facilities.

NE 6615. Fusion Fundamentals
3-0-3. Prerequisite: graduate standing in engineering or science.
A review of selected topics in mathematics and physics that are required for graduate study in fusion. Atomic processes in ionized gas, nuclear reactions, interaction of radiation with water, reactor analysis, generalized curvilinear coordinates, and Fourier analysis are covered.

NE 6623. Fusion Plasma Analysis I
3-0-3. Prerequisite: NE 4610 or consent of the School.
Covers the physics of magnetically confined plasmas at the graduate level. Topics include fundamental properties, motion of charged particles, confinement concepts, kinetic and fluid theories, equilibrium and transport.

NE 6624. Fusion Plasma Analysis II
3-0-3. Prerequisite: NE 6623.
Covers the physics of magnetically confined plasmas at the graduate level. Topics include waves and instabilities, heating and fueling, radiation, plasma-wall interaction, and power balance.

NE 6625. Fusion Reactor Technology
3-0-3. Prerequisite: NE 4610 or consent of the School.
Technology or magnetic fusion. Topics include magnets, rf and neutral beam heating, energy storage and transfer, interaction of radiation with matter, tritium breeding blankets, tritium and vacuum systems, and reactor design.

NE 6626. Plasma Equilibrium and Transport
3-0-3. Prerequisite: NE 6623.
An advanced treatment of magnetic and pressure surfaces and of transport processes in magnetically confined plasmas.

NE 6627. Plasma Waves and Instabilities
3-0-3. Prerequisites: NE 6623 and 6624 or permission of the instructor.
Study of the plasma as a dielectric medium. Normal modes and wave propagation in plasmas. Instabilities in homogeneous and inhomogeneous plasmas.

NE 6631. Fusion Nuclear Engineering I
3-0-3. Prerequisite: NE 4610 or consent of the School.

The technology of liquid and solid tritium breeding blankets, hybrid blankets, tritium fuel cycle processing systems, first wall, high heat flux components and shields in fusion experiments and future reactors.

NE 6760. Financial Management and Economics of Nuclear Power
3-0-3. Prerequisite: consent of the School.
Topics include nuclear reactor and fuel cycle, electrical power systems and utility economics, financial management and system modeling. Identical to ECON 6760.

NE 6770. Small Computer Interface Engineering and Applications
2-6-4.
The use of computers in data acquisition and control digital logic, interfacing, computer structures, and the hardware-software trade-off are covered. First course in computer engineering options.

NE 6771. Engineering Computer Software Systems
3-3-4. Prerequisite: NE 6770.
Computer programming for real-time process control systems in complex multiple-task device-oriented environments. Subjects include assembler programming, operating systems, and real-time systems on minicomputers.

NE 6772. Advanced Computer Interfacing and Digital Design
2-3-3. Prerequisite: NE 6770.
A study of system design using MSI and LSI chips and programable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

NE 6773. Computer Control of Real-time Systems
3-3-4. Prerequisite: NE 6770, EE 4077, or equivalent.
A study of concepts common to all computer-controlled real-time systems. Subjects include evolution of time sets, vectored interrupts, and statistical alarm conditions.

NE 7000. Master's Thesis
Credit to be arranged.

NE 7999. Preparation for Doctoral Qualifying Examination
Audit only. Prerequisite: consent of the School.
Students who are preparing for their qualifying examinations will be expected to register for this course. Occasionally, this may be the only course for which a student is registered.

NE 8011-2-3. Seminar
1-0-1 each.
Regularly scheduled course required of all NE majors. Various topics presented by guest speakers, faculty members, and graduate students.

NE 8110-1-2-3. Special Topics
3-0-3. Prerequisite: consent of the School.
Purpose of this course is to permit the Nuclear Engineering Program to offer formal courses on topics of special interest on an ad hoc basis.

NE 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

The student is encouraged to exercise resourcefulness and originality in attacking a problem of special interest to himself or herself and a member of the NE faculty.

NE 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

NE 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

NE 8999. Doctoral Dissertation Preparation
Audit only.

NE 9000. Doctoral Dissertation
Credit to be arranged.

HEALTH PHYSICS

HP 2401-2-3. Introduction to Health Physics I, II, III
1-0-1 each. Prerequisite: sophomore standing.
A course designed to familiarize the student with the health physics profession and the role of the health physicist in industry, medicine, and public health.

HP 4401-2-3. Health Physics Seminar
1-0-1 each. Prerequisite: consent of the School.
Intended primarily for students who plan a career in health physics. Review of current literature and current activities in the profession with class discussions.

HP 4410. Radiation Physics
3-0-3. Prerequisites: MATH 2309, PHYS 2123.
This course provides the physical basis for understanding the effects of ionizing radiation on matter, for developing a philosophy of radiation protection for individuals and the environment.

HP 4412. Principles of Health Physics
3-0-3. Prerequisite: PHYS 3001 or HP 4410.
Course emphasizes the biophysical basis of radiation protection and the development of protection criteria.

HP 4413. Applied Health Physics
3-3-4. Prerequisite: HP 4412 or consent of the School.
Practical aspects of health physics are presented, particularly radiological safety regulations and performing radiation monitoring and radioactivity measurements.

HP 4440. Effect of Nonionizing Radiation and Protection Standards
3-0-3. Prerequisites: consent of the School and HP 4412 or equivalent.
A study of methods of production and control of exposure to nonionizing radiations and a review of effects of human exposure and of the radiation protection standards.

HP 4901-2-3-4. Special Problems in Health Physics
Credit to be arranged. Prerequisite: consent of the School.
Special problems in health physics will be assigned to students based on their interests and that of a member of the NE and HP faculty. The students are encouraged to exercise resourcefulness and originality in attacking individual special problems.

HP 6401. Radiological Health Physics
3-0-3. Prerequisite: consent of the School. Corequisite: PHYS 6011 or equivalent.
An evaluation of radiation protection standards, their development and enforcement. Covers topics such as effects of radiation, internal and external exposure, health physics practice, and dosimetry.

HP 6405. Health Physics Practice
1-6-3. Prerequisite: HP 4413 or 6401 or equivalent.
A review of many types of radiation problems—both basic and applied—relating to the qualifications of a certified health physicist.

HP 6410. Radiation Dosimetry
3-0-3. Prerequisites: HP 6401 and NE 6110 or equivalent.
Fundamental principles of dosimetry of ionizing radiation: photons, charged particles, and neutrons. Cavity and interface theory. Measurements and calculation of exposure and absorbed dose.

HP 6414. Radiation Technology Laboratory
2-6-4. Prerequisite: NE 6110.
Advanced laboratory course in radiochemical and instrumental analysis of radioactivity.

HP 6421. Health Physics Internship
0-9-3. Prerequisite: by special arrangement and consent of the School.
Field training for individual graduate students in actual medical diagnostic, therapeutic, or research facilities. May be used as substitute for special problems by students in the medical health physics option. Requires grade project, formal written report, and oral presentation.

HP 6423. Physics of Radiation Therapy
2-3-3. Prerequisite: HP 6410 or consent of the School.
Physical basis of radiation therapy. Teletherapy machine calibration and quality control. Methods for dose distribution calculation for external beam and brachy therapy.

HP 6424. Radiation Oncology
2-3-3. Prerequisite: HP 6423 or consent of the School.
Description of common tumors, histology, routes of spread, treatment modalities. Methods of tumor localization and treatment planning for external beam, implants, and intracavity sources.

HP 6429. Particle Accelerators
2-3-3. Prerequisite: PHYS 6011 or consent of the School.
Principles of particle accelerators including acceleration methods, ion sources and targets, characteristics of machines such as electrostatic generators, betatrons, linear accelerators, cyclotrons, synchrotrons, and synchro-cyclotrons. Design and operation of X-ray and neutron generators covered in laboratory.

HP 6430. Radiation Protection in Nuclear Facilities
3-0-3. Prerequisites: HP 6405 or 4413, and NE 3211 or equivalent.
Review of radiation protection requirements at nuclear facilities, radiation monitoring, environmental surveillance planning, and procedures for sample analyses and waste management.

HP 6442. Applied Health Physics Laboratory
1-6-3. Corequisite: HP 6430.

A laboratory course covering practical aspects of monitoring problems in nuclear facilities and environmental surveillance analyses.

HP 6641. Environmental Surveillance and Radioactive Waste Disposal
3-0-3. Prerequisite: consent of the School.
Advanced course on environmental radioactivity and environmental aspects of nuclear power. Radioactive waste treatment, reactor effluents, and waste disposal.

HP 6643. Environmental Impact of Nuclear Power Stations
3-0-3. Prerequisite: HP 6641 or consent of the School.
Specific impact of nuclear facilities on the environment. Practical and regulatory aspects of reactor siting and the preparation of environmental impact statements.

HP 6800. Industrial Health Protection Survey
2-3-3.
A survey of the major physical and chemical hazards in the industrial environment emphasizing recognition, monitoring technology, engineering control methodology, best practice, and current regulations.

HP 7000. Master's Thesis
Credit to be arranged.

HP 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

HP 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

School of Textile Engineering

Established in 1899

Director—Albin F. Turbak; *Fuller E. Callaway Chair*—John L. Lundberg; *Professors* —Walter C. Carter, W. Denney Freeston, Wayne C. Tincher; *Associate Professors*— Wallace W. Carr, Fred L. Cook, L. Howard Olson, Malcolm B. Polk; *Assistant Professors*—Steve M. Hansen, Sundaresan Jayaraman, Dennis S. Tucker.

General Information

Textiles, one of humankind's oldest commercial ventures, continues to find new applications in the modern world. Fiber assemblies have many varied uses in our everyday life and are playing critical roles in new complex systems in space, medicine,

safety, environmental control, transportation, and construction.

Textile engineering encompasses the synthesis of polymers by nature and man, fiber fabrication processes, assembling of fibers into one-, two-, and three-dimensional structures, modification of structural properties through dyeing, finishing, and coating, and measurement of complex aesthetic and mechanical properties of fiber-based systems. New polymers and fibers, new methods of assembling fibers into useful products, and new applications of fibers are continually developing.

The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates obtain positions in manufacturing supervision, technical service, sales, product and process development, research, quality control, and corporate management. They participate in the design, development, manufacturing, and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceed the number of graduates.

Multidisciplinary Programs
See table on page 83.

Curricula

Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry, and Bachelor of Science in Textiles. Students may pursue each degree in a regular four-year program or the five-year cooperative plan.

Because of the multidisciplinary nature of textiles, the curricula stress a broad background. Emphasis in the freshman and

sophomore years is on mathematics, chemistry, and physics and in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration, and application of each field to the broad range of problems encountered in textiles. All three programs allow the student to select a number of courses from a wide range of general and technical electives.

In place of the many conventional laboratory sessions, textile students participate in a student operated and managed business venture. Students design, develop, produce, and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the textile course work is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

In addition to campuswide academic requirements for graduation with a bachelor's degree, the number of quality points earned in textile courses taken toward the degree must be at least twice the number of credit hours in those courses.

Textiles for Other Majors

Students with other majors often enter the textile industry. To further their careers, the School of Textile Engineering has developed coordinated course offerings that will be helpful to students with this goal. Listings of recommended course sequences in textiles are available in the School of Textile Engineering office.

Graduate Program

The School of Textile Engineering offers graduate programs leading to the degrees Master of Science in Textile Engineering, Master of Science, Master of Science in Textiles, Master of Science in Polymers, Master of Science in Textile Chemistry, and Doctor of Philosophy. Students holding an undergraduate degree in any one of several fields of science or engineering may qualify for admission. An undergraduate degree in textile engineering, textiles, or textile chem-

istry is not a specific requirement. Each student pursues an individually structured program.

The graduate course offerings encompass advanced study and research in polymer synthesis, mechanics of fibrous structures, process dynamics, dyeing and dye synthesis, viscoelasticity, experimental design, properties of materials, polymer flow, polymer environmental stability process control, energetics, and kinetics. The School of Textile Engineering has a variety of active research programs in which students participate.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well-equipped laboratories are also available for the chemical and physical characterization of polymers, fibers, and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing, and energy conservation and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are also housed within the building.

Bachelor of Textile Engineering Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
EGR 1170 Visual Communication and Engineering Design	.....	2-3-3	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TEX 1100 Introduction to Textile Engineering	3-0-3	.....	.....
TEX 2180 Textile Manufacturing Processes I	.....	0-3-1	.....

TEX 3400 Computer Applications in Textiles	.....	.....	2-3-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
TOTALS	15-3-16	14-9-17	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 2201 Statics	3-0-3	.....	.....
ESM 3201 Dynamics I	.....	3-0-3	.....
MATH 2307-8-9 Calculus IV, V, VI	5-0-5	5-0-5	5-0-5
PHYS 2122-3 Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	.....
ICS 2250 Technical Information Resources	1-0-1	.....	.....
TEX 2105 Introduction to Textile/Polymer Chemistry	3-0-3	.....	.....
TEX 4200 Fiber Science	.....	3-0-3	.....
ISYE 3028 Engineering Statistics I	.....	.....	3-0-3
ENGL 3020 Technical Writing	.....	.....	3-0-3
Humanities/Social Sciences/Modern Languages Electives	.....	3-0-3	3-0-3
Free Elective	.....	.....	3-0-3
TOTALS	16-3-17	18-3-19	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3301 Mechanics of Deformable Bodies	5-0-5	.....	.....
MET 3301 Principles and Applications of Engineering Materials	.....	4-3-5	.....
ME 3180 Mechanical Design I	.....	.....	3-0-3
ME 3322-3 Thermodynamics I, II	3-0-3	.....	3-0-3
TEX 4750 Polymer Science and Engineering I	.....	3-0-3	.....
TEX 4201-2 Mechanics of Fibrous Structures I, II	3-0-3	3-0-3	.....
TEX 2181-2 Textile Manufacturing Processes II, III	0-3-1	0-3-1	.....
TEX 3600 Elementary Heat and Mass Transfer	.....	.....	3-3-4
EE 3701 Electric Circuits	.....	.....	2-0-2
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Electives	3-0-3	3-0-3	3-0-3
TOTALS	17-3-18	16-6-18	17-3-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 4305 Chemical Preparation and Finishing of Textiles	.....	3-0-3	.....
ME 3340 Fluid Mechanics I	.....	.....	3-0-3
EE 3702 Elementary Electronics	2-0-2	.....	.....
EE 3400 Instrumentation Laboratory	1-3-2	.....	.....
EE 3703 Electric Power Conversion	.....	2-0-2	.....
EE 4421 Senior Electrical Engineering Laboratory II	.....	0-3-1	.....
TEX 4306 Dyeing and Printing	.....	.....	3-3-4
TEX 4420 Analysis of Textile Materials	3-3-4	.....	.....
ISYE 4725 Engineering Economy	.....	3-0-3	.....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 3480-1 Textile Manufacturing Processes IV, V	0-3-1	0-3-1	.....
TEX 3484 Problems in Textile Management II	.....	.....	0-3-1
TEX 4900-1 Special Problems	0-3-1	0-3-1	.....
TEX 4751 Polymer Science and Engineering II	3-0-3	.....	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	6-0-6
TOTALS	13-12-17	12-9-15	13-6-15

ELECTIVES

Humanities/Social Sciences/Modern Languages Electives

See the "Information for Undergraduate Students" section pp. 41-42 for humanities, social sciences, and modern languages requirements. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

Twelve hours of electives must be approved by the School. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit. The ROTC student may replace TEX 4405-6-7 with the thirteenth through fifteenth credit hours of ROTC.

Bachelor of Science in Textiles Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
MATH 1711-2-3 Mathematics for Management I, II, III	5-0-5	5-0-5	5-0-5
TEX 1100 Introduction to Textile Engineering	3-0-3	.....	.....
TEX 2180 Textile Manufacturing Processes I	.....	0-3-1	.....
TEX 2103 Yarn Processing	.....	.....	3-0-3
TEX 3400 Computer Applications in Textiles	.....	.....	2-3-3
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	.....	X-X-3
Elective	.....	3-0-3	.....
TOTALS	15-3-16	15-6-17	X-X-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2111-2-3 Physics	4-0-4	4-0-4	4-0-4
ENGL 3020 Technical Writing	.....	.....	3-0-3
ECON 2000-1 Economic Principles and Problems	.....	3-0-3	3-0-3
TEX 2105 Introduction to Textile/Polymer Chemistry	3-0-3	.....	.....
ICS 2250 Technical Information Resources	1-0-1	.....	.....
TEX 2104 Yarn Processing II	3-0-3	.....	.....
TEX 3110 Woven Structures I	.....	3-0-3	.....
TEX 3112 Knit Fabrics	.....	.....	3-0-3
TEX 2181-2 Textile Manufacturing Processes II, III	.....	0-3-1	0-3-1
Electives	6-0-6	6-0-6	3-0-3
TOTALS	17-0-17	16-3-17	16-3-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 3113 Nonwoven Fabrics	3-0-3	.....	.....
TEX 4122 Chemical Structures and Physical Properties of Polymers	3-0-3	.....	.....
TEX 4300 Chemistry and Chemical Processing of Fibers and Textiles I	.....	.....	3-0-3
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	.....

Column 1

MGT 3060
Financial Management 3-0-3

MGT 3300
Marketing I 3-0-3 ....

TEX 4200
Fiber Science ..... 3-0-3 .....

ISYE 3028
Engineering Statistics I 3-0-3

TEX 3480-1-2
Textile Manufacturing
Processes IV, V, VI 0-3-1 0-3-1 0-3-1

TEX 3483-4
Problems in Textile
Management I, II 0-3-1 0-3-1 .....

Electives 3-0-3 9-0-9 6-0-6

TOTALS 15-6-17 15-6-17 15-3-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 4420 Analysis of Textile Materials	3-3-4	.....	.....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 4100 Textile Management Decision Making	.....	2-3-3	.....
TEX 4101 Planning and Control in Textile Production Systems	.....	.....	3-0-3
PSY 4401 Industrial Psychology	.....	.....	3-0-3
MGT 4200 Industrial Relations	.....	.....	3-0-3
ISYE 3115 ISYE Measurements	3-0-3	.....	.....
MGT 3150 Industrial Management Principles	.....	3-0-3	.....
TEX 3485 Problems in Textile Management III	0-3-1	.....	.....
TEX 4480 Problems in Production Supervision	0-3-1	.....	.....
TEX 4301 Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	.....	.....
TEX 4302 Textile Finishing Processes	.....	3-0-3	.....

Column 2

TEX 4481-2
Advanced Problems in
Textile Management
and Production Innovation

or

TEX 4900-1
Special Problems 0-3-1 0-3-1

Electives 3-0-3 3-0-3 6-0-6

TOTALS 13-12-17 12-6-14 16-3-17

ELECTIVES

Humanities/Social Sciences/Modern Languages Electives

See "Information for Undergraduate Students" section of this catalog, pp. 41-42, for humanities, social sciences, and modern languages requirements. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

Twelve hours of electives must be approved by the School. Elective courses may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

Bachelor of Science in Textile Chemistry Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
CHEM 2113 Chemical Principles	.....	.....	3-3-4
TEX 1100 Introduction to Textile Engineering	3-0-3	.....	.....
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
TEX 2180 Textile Manufacturing Process I	.....	0-3-1	.....
TEX 3400 Computer Applications in Textiles	.....	.....	2-3-3

Column 3

	1st Q.	2nd Q.	3rd Q.
Humanities/Social Sciences/Modern Languages Elective	.....	.....	3-0-3
Physical Education (requirements, p. 253)	.....	.....	X-X-3
Elective	.....	3-0-3	.....
TOTALS	15-3-16	15-6-17	X-X-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381-2 Organic Chemistry Laboratory	.....	0-6-2	0-6-2
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
PHYS 2121 Particle Dynamics	4-3-5	.....	.....
PHYS 2122 Electromagnetism	.....	4-3-5	.....
PHYS 2123 Optics and Modern Physics	.....	.....	4-3-5
TEX 2103 Yarn Processing I	.....	.....	3-0-3
ENGL 3020 Technical Writing	.....	.....	3-0-3
ICS 2250 Technical Information Resources	.....	.....	1-0-1
Electives	6-0-6	3-0-3	.....
TOTALS	18-3-19	15-9-18	14-9-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 3412-3 Physical Chemistry	3-0-3	3-0-3	.....
CHEM 3481 Physical Chemistry Laboratory	.....	0-6-2	.....
ISYE 3028 Engineering Statistics I	3-0-3	.....	.....
TEX 4310 Textile Instrumental Analysis	.....	.....	2-3-3
TEX 3600 Elementary Heat and Mass Transfer	.....	.....	3-3-4
TEX 3110 Woven Structures I	.....	3-0-3	.....

Column 4

TEX 4750
Polymer Science and
Engineering I ..... 3-0-3 .....

TEX 4200
Fiber Science 3-0-3 ....

TEX 4300
Chemistry and
Chemical Processing of
Fibers and Textiles 1 3-0-3

Electives 9-0-9 6-0-6 6-0-6

TOTALS 18-0-18 15-6-17 14-6-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 4420 Analysis of Textile Materials	3-3-4	.....	.....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 4301 Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	.....	.....
TEX 4302 Textile Finishing Processes	.....	3-0-3	.....
TEX 4503 Science of Color	.....	3-0-3	.....
TEX 4504 Fiber Extrusion, Drawing and Texturing	.....	.....	3-0-3
TEX 4751 Polymer Science and Engineering II	3-0-3	.....	.....
TEX 4760 Polymer Science and Engineering Laboratory	.....	.....	1-6-3
Polymer Elective	.....	3-0-3	.....
TEX 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
TEX 4900-1 Special Problems	.....	0-3-1	0-3-1
Electives	3-0-3	3-0-3	6-0-6
TOTALS	13-9-16	13-6-15	11-12-15

SUBSTITUTIONS

CHEM 1111-2 can be substituted for CHEM 1101-2. CHEM 4201 can be substituted for TEX 4310.

ELECTIVES

Humanities/Social Sciences/Modern Languages Electives

See the "Information for Undergraduate Students" section of this catalog (pp. 41-42) for humanities, social sciences, and modern languages requirements. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

Fifteen hours of electives must be approved by the School. Elective courses may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit. One course is designated as a polymer elective. This course must be one not in the required curriculum and must be approved by the School.

Courses of Instruction

TEX 1100. Introduction to Textile Engineering
3-0-3. An introduction to textile chemistry, textile engineering and textile management, textiles, fibers, and polymers and to the textile-fiber-polymer-chemical-equipment-engineering industrial complex. Credit cannot be obtained for both TEX 1100 and TEX 2701.

TEX 2103. Yarn Processing I
3-0-3. Prerequisite: TEX 1100.
Fundamental principles of processing natural and man-made staple fibers into yarns; basic properties of spun yarns.

TEX 2104. Yarn Processing II
3-0-3. Prerequisite: TEX 2103.
Fundamental principles of processing natural and man-made staple fibers into yarns; basic properties of spun yarn.

TEX 2105. Introduction to Textile/Polymer Chemistry
3-0-3. Prerequisite: CHEM 1102.
An introduction to the chemistry of polymers and textile fibers, preparation agents, dyes, and finishes. Not open to majors requiring organic chemistry courses in their curricula.

TEX 2180. Textile Manufacturing Processes I
0-3-1. Prerequisite or corequisite: TEX 1100.
Orientation to manufacturing and management operations in the student-operated enterprise.

TEX 2181. Textile Manufacturing Processes II
0-3-1. Prerequisite: TEX 2103 or consent of the School.
Yarn production operations within the student-operated enterprise.

TEX 2182. Textile Manufacturing Processes III
0-3-1. Prerequisite: TEX 3110 or consent of the School.
Woven fabric production operations within the student-operated enterprise.

TEX 2500. Survey of Apparel Manufacturing
3-0-3.
Apparel engineering and manufacturing, from planning and receipt of raw materials to the distribution of finished garments.

TEX 2700. Survey of Polymer and Fiber Technology
3-0-3. Not open to textile students.
An introduction to the history, structure, properties, fabrication, and use of polymers in the textile and related industries.

TEX 2701. Textile Industry Survey
3-0-3. Not open to textile students.
An overview of textiles, fibers, and polymers and the associated complex of industries from raw materials to finished products, including textile arts and textile management. Credit cannot be obtained for both TEX 1100 and TEX 2701.

TEX 2702. Survey of Fibrous Materials
3-0-3. Not open to textile students.
A survey of natural and man-made fibers used in the textile industry.

TEX 3110. Woven Structures I
3-0-3. Prerequisite: TEX 2104.
The weaving process and woven fabric construction, design, and properties are studied.

TEX 3111. Woven Structures II
3-0-3. Prerequisite: TEX 3110.
Dynamics, operating characteristics, and economics of new weaving machines.

TEX 3112. Knit Fabrics
3-0-3. Prerequisite: TEX 2103.
A study of warp and weft knit fabric production, properties, and design. Description of knitting machines as related to fabric design and control of properties.

TEX 3113. Nonwoven Fabrics
3-0-3. Prerequisite: TEX 2103.
Chemically and mechanically bonded nonwoven fabrics, fabric formation processes, design, and properties.

TEX 3400. Computer Applications in Textiles
2-3-3. Prerequisite: MATH 1711 or 1307 or consent of the School.
Computer techniques are applied to textile engineering problems. An assembler language introduces FORTRAN. Applications include digital and analog interfaces to textile processes.

TEX 3480. Textile Manufacturing Processes IV
0-3-1. Prerequisite or corequisite: TEX 3112 or consent of the School.
Knit fabric production operations within the student-operated enterprise.

TEX 3481. Textile Manufacturing Processes V
0-3-1. Prerequisite: consent of the School.
Evaluation of products produced by the student-operated enterprise.

TEX 3482. Textile Manufacturing Processes VI
0-3-1. Prerequisite: TEX 4305 or consent of the School.
Fabric finishing operations within the student-operated enterprise.

TEX 3483. Problems in Textile Management I
0-3-1. Prerequisite: MGT 2000, 3300, or consent of the School.
Product marketing and cost accounting within the student-operated enterprise.

TEX 3484. Problems in Textile Management II
0-3-1. Prerequisite: consent of the School.
Methods of plant maintenance and work studies within the student-operated enterprise.

TEX 3485. Problems in Textile Management III
0-3-1. Prerequisite: consent of the School.
Personnel administration, scheduling, and planning within the student-operated enterprise.

TEX 3500. Jacquard Design and Weaving
2-3-3. Prerequisite: TEX 3110.
The designing of Jacquard patterns and the techniques involved in the transfer of design to the fabric.

TEX 3510. Materials Preparation, Pattern Analysis, and Cutting in Garment Manufacture
3-0-3. Prerequisite: TEX 2500.
Methods, mechanics, and analysis of materials preparation, pattern drafting and cutting in garment manufacture, with emphasis on new methods and automation.

TEX 3511. Garment Assembly
4-0-4. Prerequisite: TEX 2500.
Formation and mechanics of seaming, including thread properties, stitch formation, sewing machines, heat sealing and ultrasonic, radio frequency, infrared and adhesive bonding.

TEX 3512. Apparel Production, Planning, and Engineering
4-0-4. Prerequisite: TEX 3510 or consent of the School.
Analysis and design of apparel production from raw materials to finished product, with emphasis on maximizing quality and productivity and minimizing time, cost, and waste.

TEX 3513. Apparel Shaping and Finishing
4-0-4. Prerequisite: TEX 3512 or consent of the School.
Principles and analysis of processes for shaping and finishing apparel, with emphasis on design of systems and equipment for maximizing the quality/cost ratio.

TEX 3600. Elementary Heat and Mass Transfer
3-3-4. Prerequisites: MATH 1308, PHYS 2123, ME 3322, or CHEM 3412.
Unit operations of chemical engineering emphasizing applications to fibers and textiles.

TEX 3700. Survey of Fiber Processing
3-0-3. Not open to textile students.
A survey course in yarn manufacturing covering principles of processing natural and synthetic fibers.

TEX 3701. Survey of Fabric Production
3-0-3. Not open to textile students.
A survey of fabric assemblies including woven, knit, nonwoven, and flexible composite structures. Discussion includes processing, design, and mechanical behavior.

TEX 3702. Survey of Dyeing and Finishing of Textile Materials
3-0-3. Not open to textile students.
Dyeing and finishing of textile materials made from natural and synthetic fibers.

TEX 3800. Special Topics
1-0-1. Prerequisite: consent of the School.
Studies of topics of current interest and concern to the textile industry.

TEX 4100. Textile Management Decision Making
2-3-3. Prerequisite: senior standing.
Students practice making management decisions in a competitive market using computer simulations of textile manufacturing operations.

TEX 4101. Planning and Control in Textile Production Systems
3-0-3. Prerequisite: ISYE 3028.
A study of the basic planning and control functions required in textile production systems, including design of production facilities, analysis, and control of inventory systems and production planning.

TEX 4122. Chemical Structures and Physical Properties of Polymers
3-0-3. Prerequisite: CHEM 1102 or consent of the School. Not open to textile chemists, chemists, or chemical engineers.
A fundamental review of organic polymers, including polymerization methods, chemical structures, and structure/property relationships.

TEX 4200. Fiber Science
3-0-3. Prerequisite: PHYS 2121 or 2111.
The physical structure and properties of fibers are examined and related to end-use performance.

TEX 4201. Mechanics of Fibrous Structures I
3-0-3. Prerequisite: TEX 4200 or consent of the School.
Yarn processing with emphasis on relationships between fiber properties and yarn properties.

TEX 4202. Mechanics of Fibrous Structures II
3-0-3. Prerequisite: TEX 4200 or consent of the School.
Processes, properties, and mechanics involved in the manufacture of woven and knitted fabrics.

TEX 4203. Mechanics of Fibrous Structures III
3-0-3. Prerequisite: TEX 4200 or consent of the School.
Investigation of production processes, structures, and properties of adhesive and mechanically bonded nonwoven fabrics and fiber-reinforced materials.

TEX 4300. The Chemistry and Chemical Processing of Fibers and Textiles I
3-0-3. Prerequisite: TEX 4750 or 4122.
The structure and purification of natural and synthetic fibers, with emphasis on the relationship of fiber structure and behavior during chemical processing.

TEX 4301. The Chemistry and Chemical Processing of Fibers and Textiles II
3-3-4. Prerequisite: TEX 4750 or 4122 or consent of the School.
The dyeing and printing of textile materials, with emphasis on the relationship of fiber structure and response of textiles to these processes.

TEX 4302. Textile Finishing Processes
3-0-3. Prerequisite: TEX 4750 or 4122 or consent of the School.
The chemical and mechanical finishing of textile materials to impart desired properties, with emphasis on the relationship of fiber structure and response of textiles to these processes.

TEX 4305. Chemical Preparation and Finishing of Textiles
3-0-3. Prerequisite: ME 3180, TEX 3600 and 4750 or consent of the School.
The chemical, thermal, and mechanical processes used in the preparation and finishing of fibers, yarns, and fabrics.

TEX 4306. Dyeing and Printing
3-3-4. Prerequisite: ME 3180, TEX 3600 and 4750 or consent of the School.
The application of dyes and pigments to fibers, yarns, and fabrics.

TEX 4310. Textile Instrumental Analysis
2-3-3. Prerequisite: CHEM 1102, 1112, or consent of the School.
The theory and practice of modern instrumental methods as used in the analysis of textile chemicals, with emphasis on spectroscopy, chromatography, colorimetry, and differential thermal analysis.

TEX 4401. Introduction to Textile Literature
1-0-1. Prerequisite: TEX 1100.
Sources of textile information and an introduction to search techniques for the textile information system.

TEX 4405-6-7. Seminar
1-0-1 each. Prerequisite: senior standing. TEX 4405 and 4406 are to be taken audit only and are prerequisites for TEX 4407.
Presentations by invited speakers on new developments in textiles, job opportunities, and graduate education.

TEX 4420. Analysis of Textile Materials
3-3-4. Prerequisites: TEX 4200, 4122, or 4751, ISYE 3028, or consent of the School.
The methods used in the textile industry for assessing the effects of process variables on the end use performance of textile products are examined.

TEX 4480. Problems in Production Supervision
0-3-1. Prerequisites: TEX 2180-1-2, 3480-1.
Supervision of the student-operated enterprise production operations. Solving day-to-day problems in logistics, personnel relations, and manufacturing technology.

TEX 4481. Advanced Problems in Textile Management
0-3-1. Prerequisites or corequisites: TEX 3483-4-5.
Supervision of one of the student-operated enterprise's staff level departments.

TEX 4482. Product Innovation
0-3-1. Prerequisite or corequisite: TEX 4480.
The student is part of a small entrepreneurial team developing new products for the student-operated enterprise.

TEX 4483. Special Problems in Textile Industrial Operations
0-6-2. Prerequisite: TEX 3702 or consent of the School.
Available to textile and nontextile students who want to engage in special projects that involve the personnel or facilities of the student-operated enterprise.

TEX 4500. Technology of Carpet Manufacturing
3-0-3. Prerequisite: TEX 1100.
A study of materials and production systems used in carpet manufacturing. Carpet performance characteristics, dyeing, backcoating, and nonwoven carpet manufacturing methods are examined.

TEX 4502. Fiber-reinforced Materials
3-0-3. Prerequisite: TEX 4751 or 4200, or consent of the School.
Principles and engineering behavior of flexible and rigid fiber-reinforced composites. Topics include influence of matrix, interface and voids, fabrication, fracture and fatigue characterization, evaluation of specific composite systems.

TEX 4503. Science of Color
3-0-3. Prerequisite: CHEM 1102 or 1112, PHYS 2113 or consent of the School.
The physical, chemical, and biological principles involved in perception, measurement, and specification of color.

TEX 4504. Fiber Extrusion, Drawing, and Texturing
3-0-3. Prerequisite: TEX 4751, 3600 or consent of the School.
Rheology mechanics, energetics, kinetics, phase transitions, and polymer structure in fiber formation by melt, dry, wet and reactive spinning, and drawing and texturing of fibers.

TEX 4505. Structure and Mechanics of Knit Fabrics
3-0-3. Prerequisite: TEX 3112 or 4201, or consent of the School.
The basic geometries of fabrics produced by warp and weft knitting, overall physical properties of knit fabrics, and fabric stress distribution.

TEX 4750. Polymer Science and Engineering I
3-0-3. Prerequisites: CHEM 1102 or 1112 and PHYS 2123 or consent of the School.
An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems, and methods of identification of polymers are presented. Also taught as CHE 4750.

TEX 4751. Polymer Science and Engineering II
3-0-3. Prerequisites: CHEM 1102 or 1112 and PHYS 2123 or consent of the School.
An introduction to the physical states and transitions, fabrication processes, and mechanical properties of polymers. Also taught as CHE 4751.

TEX 4753. Survey of Pulp and Paper Technology
3-0-3.
The mechanical systems used in paper manufacture. Chemistry of pulp preparation and nonfibrous additives. Also taught as CHE 4753.

TEX 4760. Polymer Science and Engineering Laboratory
1-6-3. Prerequisite: TEX 4751.

Experiments in polymerization, processing, and property evaluation of polymers. Also taught as CHE 4760.

TEX 4773. Paper Formation and Properties
3-0-3. Prerequisite: consent of the School.
The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as CHE and ME 4773.

TEX 4800-1-2. Special Topics
3-0-3 each. Prerequisite: consent of the School.
Studies of topics of current interest and concern to the textile industry.

TEX 4900-1. Special Problems
Credit to be aranged. Prerequisite: consent of the School.
Special problems involving analytical and/or experimental investigations in the field of textiles.

TEX 6100. Advanced Fiber Science
3-0-3. Prerequisite: graduate standing.
Physical properties, mechanical properties, and microstructure of polymeric fibers are examined and related to end-use performance.

TEX 6101. Textile Testing and Evaluation
3-3-4. Prerequisite: graduate standing.
Study of methods used to characterize properties that are important to an understanding of behavior of fibers, yarns, and fabrics.

TEX 6200. Physical Methods of Investigating Textiles
3-6-5. Prerequisite: ISYE 3028, TEX 4420, or consent of the School.
Study of modern techniques and instrumentation for the evaluation of physical properties of fibers, yarns, and fabrics.

TEX 6201. Process Control in the Textile Industry
3-0-3. Prerequisite: TEX 3400 or consent of the School.
Computer techniques are applied to problems in scheduling production equipment and in control of quality, inventories, and production. Topics include interfacing, costs, programming.

TEX 6210. Dynamics of Fiber Processing Systems I
3-0-3. Prerequisites: TEX 4200, 4201, or consent of the School.
The dynamic interaction of fibers and fiber assemblies during processing is examined. The effects of fiber and bundle properties on processing variables are analyzed.

TEX 6211-2. Dynamics of Fiber Processing Systems II, III
3-0-3 each. Prerequisite: TEX 6210 or consent of the School.
The dynamics of fabric forming mechanisms are examined. Weaving, knitting, sewing, heating, and drying are typical processes that are considered.

TEX 6300. Preparation and Reactions of Polymers
3-0-3. Prerequisites: TEX 4750.
A detailed treatment of the reactions involved in the synthesis of both man-made and natural polymers, including preparative and degradative reactions in polymer systems.

TEX 6320. Fundamental Aspects of Dyeing Processes
3-0-3. Prerequisites: TEX 4301, 4750, 4751 or consent of the School.
Models required for the interpretation of the dyeing behavior of textile materials are examined in order to provide useful semiquantitative descriptions of dye processes.

TEX 6321. Chemical Technology of Stabilization Processes
3-0-3. Prerequisite: TEX 4302 or 4305, or consent of the School.
A comprehensive treatment of finishing processes used in the textile industry to impart desirable end-use performance characteristics to textile materials.

TEX 6400. Information Processes in Textile Science and Engineering
3-0-3. Prerequisite: TEX 3400 or consent of the School.
Information aspects of textile science and technology; use of computers in acquisition, processing, and utilization of information and knowledge in textile research and production.

TEX 6755. Polymer Structure and Mechanical Properties
3-0-3. Prerequisite: TEX 4751 or CHE 4751 or consent of the School.
Fundamental aspects of the development and analysis of structure, and molecular and phenomenological models of mechanical behavior of solid-like polymers. Also taught as CHE 6755 and ME 6755.

TEX 6756. Mechanical Properties of Polymers
3-0-3. Prerequisite: TEX 4751 or CHE 4751 or consent of the School.
Mechanics of deformation of anisotropic polymers, such as yield, breaking, and fatigue in the mechanical behavior of polymers; engineering applications. Also taught as CHE 6756 and ME 6756.

TEX 6757. Rheology of Non-Newtonian Fluids
3-0-3. Prerequisites: an undergraduate course in fluid mechanics and TEX 4751 or CHE 4751, or a polymer rheology and processing course, or consent of the instructor.
Linear and nonlinear models for non-Newtonian viscous and viscoelastic behavior of polymer fluids; theoretical predictions and their comparison with experimental response. Also taught as CHE 6757.

TEX 7000. Master's Thesis

TEX 7210. Recent Advances in Textile Manufacturing
3-0-3. Prerequisite: consent of the School.
A detailed review of significant new processes, techniques, and machines in the textile industry.

TEX 7220. Fiber Mechanics
3-0-3. Prerequisite: consent of the School.
The tensile, compressive, bending, and torsional response of fibers. Fiber anisotropy and linear and nonlinear time-dependent response are studied.

TEX 7221. Mechanics of Linear Assemblies
3-0-3. Prerequisite: consent of the School.
The tensile, bending, and torsional response of continuous filament, staple and blended single yarns, the tensile

response of plied yarns, cords, and ropes, the tensile response of braided cords.

TEX 7222. Mechanics of Planar Assemblies
3-0-3. Prerequisite: consent of the School.
A state-of-the-art study of woven, knit, and nonwoven fabric mechanics.

TEX 7311. Polymer Degradation
3-0-3. Prerequisite: TEX 4750, 4751, or consent of the School.
A study of the physical and chemical changes in polymeric materials exposed to hostile environments during processing and use.

TEX 7313. Dye Synthesis
3-0-3. Prerequisite: consent of the School.
The industrial chemistry of dyes and their intermediates is covered. Structure is related to color, fastness, and affinity. Lapworth nomenclature and recent patents are surveyed.

TEX 7751. Energetics
3-0-3. Prerequisite: consent of School.
Energetics applied to polymers and fibers using Newtonian mechanics, thermodynamics, statistical thermodynamics, and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials.

TEX 7752. Kinetics
3-0-3. Prerequisite: consent of School.
Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes, and irreversible thermodynamics.

TEX 7777. Polymer Solutions and Surfaces
3-0-3. Prerequisite: consent of the instructor.
Study of polymer solutions, absorptions, sorptions, plasticization, molecular weights, molecular weight distribution, and interfacial phenomena, using thermodynamics, statistical mechanics, information and fluctuation theories, and relaxation methods. Also taught as CHE 7777.

TEX 7999. Preparation for Doctoral Qualifying Exams

TEX 8003-4-5. Seminar
1-0-1 each. Audit only.

TEX 8100-1-2. Special Topics in Textile Science and Engineering
3-0-8 each. Prerequisite: consent of the School.
Topics of current interest in textile science and engineering.

TEX 8500-1-2. Special Problems in Textiles and Textile Engineering
Credit to be arranged.

TEX 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

TEX 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

TEX 9000. Doctoral Thesis

Established in 1969, School in 1948, Department in 1934, School of Commerce in 1913

Dean—Gerald J. Day; *Associate Dean*—Joseph Reitz, Jr., *Assistant Deans*—Andrew J. Cooper III, Marilu H. McCarty; *Fuller E. Callaway Chair*—Eugene E. Comiskey; *Mills B. Lane Professor in Finance and Banking*—Bernell K. Stone; *Regents' Professor Emeritus*—Sherman F. Dallas; *Professors*—Philip Adler, Jr., Fred C. Allvine, William Carl Biven, Robert W. Carney, Kong Chu, Gerald J. Day, Robert Earl Green, David M. Herold, Robert G. Jeroslow, Ferdinand K. Levy, Mack A. Moore, Roderick F. O'Connor, Leonard J. Parsons, William A. Schaffer, Matthew J. Sobel, Fred A. Tarpley, Jr.; *Associate Professors*—Thomas D. Boston, Andrew J. Cooper III, John R. Kaatz, Jackie Kleiner, Naresh K. Malhotra, David C. Nachman, Charles K. Parsons, Peter G. Sassone, Stephen D. Smith, Kishore Tandon, Richard D. Teach; *Assistant Professors*—Ben Hsien Bao, Terry C. Blum, Kevin C. W. Chen, Bryan K. Church, Jeffrey G. Covin, Naveen Donthu, Narayanan Jayaraman, Robert C. Liden, William S. Lovejoy, Charles W. Mulford, Jr., Dennis H. Nagao, Teresa M. Pavia, Arnold Schneider, Deborah Turner.

General Information
The College of Management provides education of the highest quality to prepare students for careers as managers or for additional study at the graduate level. The increasing number of organizations and the growing complexity of modern industrial and governmental operations have resulted in a great need for college graduates with formal preparation in management and economics.

The College of Management offers three undergraduate programs leading to the Bachelor of Science in Management, the Bachelor of Science in Management Science, and the Bachelor of Science in Economics. All three degree programs follow a common core curriculum with only minor exceptions. However, each program allows sufficient flexibility for the student to develop and follow his or her own educational goals.

Problem solving takes place in a complex technical, social, and political environment. Students can sharpen the basic tools of management and economics by understanding the natural, life, and social sciences, exploring the environment of the business enterprise, and gaining knowledge of the internal activities of the enterprise itself. Thus, every student is required to take course work in laboratory science, humanities, and the social sciences. Students become familiar with the fundamental activities of management by taking courses such as accounting, economics, computer applications, marketing, production, and finance. The use of computers is an integral part of the College program. Ownership of a personal computer is encouraged, though not required.

Graduate work in the College leads to the Master of Science and the Doctor of Philosophy in Management.

Certificate Program in Economics
In addition to its degree programs, the College of Management offers students in good standing an opportunity to broaden their areas of expertise or aquire skills or information beyond their major degree requirements. Students who satisfactorily complete this special program will receive a certificate of recognition.

The College of Management offers a certificate in economics for students in other degree programs at Georgia Tech. The certificate program provides a general acquaintance with the economics discipline and is especially useful for students considering graduate work in law or business administration. It should also be attractive to students who wish to broaden their education and to understand the forces that shape the modern world.

The certificate requires a minimum of eighteen quarter hours of economics courses in which a grade of C or better is earned. These should include the following:

ECON 2000 Principles of Economics (micro)
ECON 2001 Principles of Economics (macro)
ECON 3000 Intermediate Microeconomics
ECON 3001 Intermediate Macroeconomics
or
ECON 3002 Money and Banking

and two or more electives from the following:

ECON 3095 Seminar in Economic Policy
ECON 3100 Econometrics I
ECON 3410 Economic Development
ECON 4000 Topics in Advanced Microeconomics
ECON 4050 Monetary Theory and Policy
ECON 4110 Mathematical Economics
ECON 4120 Economic Forecasting
ECON 4231 Labor History
ECON 4235 Protective Labor Legislation
ECON 4265 Labor Relations Law
ECON 4300 International Economics
ECON 4320 Managerial Economics
ECON 4330 Regional Economics
ECON 4331 Urban Economics
ECON 4340 Economics of Industrial Concentration
ECON 4400 History of Economic Thought
ECON 4410 Industrial Development in Latin America
ECON 4803 Special Topics in Economics

Students enrolled in the College of Management may receive a certificate in economics by earning a grade of C or better in any four of the above courses, excluding those that are part of the required curriculum (ECON 2000, 2001, and two from 3000, 3001, and 3002).

Bachelor of Science in Management

Students with a broad interest in all management activities and operating problems should profit from the management degree program. The program builds upon knowledge of the functional, environmental, behavioral, economic, and legal aspects of business and provides analytic and conceptual tools for analyzing complicated problems. It prepares the student for managerial responsibilities and decision making. The large number of elective hours allows the student, with his or her adviser, to tailor a program to his or her individual educational objectives. Students may take a concentration of electives in areas such as organizational behavior, finance, accounting, computer applications, marketing, industrial relations, and general management.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Science Electives	X-X-4	X-X-4	X-X-4
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2101, 2201, 2301, or 2401 Introduction to Literature or Drama and Film	.....	.....	3-0-3
Social Sciences Electives or Modern Languages Electives	3-0-3	3-0-3	3-0-3
Mathematics	5-0-5	5-0-5	5-0-5
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TOTALS	X-X-15	X-X-15	X-X-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Engineering/Science/ Mathematics/ Architecture Electives	X-X-3	.....	X-X-3
MSCI 3100 Survey of Statistics	.....	3-0-3	.....
Literature Electives	3-0-3	3-0-3	3-0-3
ECON 2000-1 Principles of Economics I, II	.....	3-0-3	3-0-3
MGT 2000-1-2 Accounting I, II, III	3-0-3	3-0-3	3-0-3
MSCI 2000 Management Applications of Data Processing	2-3-3	.....	.....
Nonmanagement Electives	3-0-3	3-0-3	3-0-3
TOTALS	X-X-15	X-X-15	X-X-15

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ECON 3000, 3001, or 3002 Intermediate Economics	3-0-3	3-0-3	.....
Engineering/Science/ Mathematics/ Architecture Elective	X-X-3	.....	.....
MSCI 3400 Analytical Methods in Management I	.....	3-0-3	.....
MGT 3260 or 3261 Law I or Law II	.....	.....	3-0-3
MGT 3060 Finance I	3-0-3	.....	.....
MGT 3300 Marketing I	3-0-3	.....	.....
Marketing Elective	.....	3-0-3	.....
ENGL 3015 Public Speaking	.....	.....	3-0-3
MGT 3150 Management Theory	3-0-3	.....	.....
College Approved Electives	.....	3-0-3	3-0-3
MGT 4350 Production Management	.....	.....	3-0-3
MGT 3061 Finance II or MGT 3070 Science Models in Finance	.....	3-0-3	.....
MGT 4200 Industrial Relations	.....	.....	3-0-3
TOTALS	15-0-15	15-0-15	15-0-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
MGT 3100, 4100, or 4110 Organizational Behavior Elective	3-0-3	.....	.....
College Approved Electives	3-0-3	6-0-6	3-0-3
MGT 4155 Fundamentals of World Business	3-0-3	.....	.....
Free Electives	3-0-3	6-0-6	9-0-9
Social Sciences Electives or Modern Languages Electives	3-0-3	3-0-3	.....
MGT 4195 Integrated Management Problems	.....	.....	3-0-3
TOTALS	15-0-15	15-0-15	15-0-15

REQUIREMENTS
Mathematics

The mathematics requirement may be satisfied by one of the following sequences: MATH 1711-2-3; MATH 1307-8, and 1711; or MATH 1307-8-9, and 2307-8. Students may not register for MATH 1307 and 1712 or MATH 1308 and 1713. Courses must be taken and passed in sequence; concurrent registration for two or more of these courses is not permitted. Transfer students into the College must consult with the Management Office to determine their mathematics requirement at the time of transfer.

ELECTIVES
Science Electives

One year of science is required in chemistry, biology, or physics. Students must complete a series in one area.

Social Sciences Electives

Students must complete eighteen hours in the social sciences (see pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement and part of the total eighteen-hour requirement.

Psychology courses may be used to fulfill part of the eighteen hours in the social sciences in the senior year only (see pp. 41-42 for the allowed psychology courses).

Modern Languages Electives
Modern languages courses are encouraged by the College for students interested in international business. Although any level of modern languages courses may be taken, only certain courses on the 2000 level and higher may be applied to the eighteen-hour social sciences requirement (see pp. 41-42).

Physical Education Elective
No student may receive credit for more than three hours of physical education toward a degree. See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, p. 253, for freshman physical education requirements. The three-hour requirement can be fulfilled during any quarter of the freshman year.

Engineering/Science/Mathematics/ Architecture Electives
One year is required of approved engineering courses, architecture, science, or advanced math not required by the core curriculum. Students should consult the *Management Handbook* for restrictions.

Literature Electives
Students must complete nine hours of humanities selected from the English Department's programs in Drama and Film, American Literature, Literature and Science, and the Western Tradition in Literature and Art, or from the Modern Languages Department's courses above the 2000 level that carry humanities credit, excluding linguistics.

Nonmanagement Electives
Any course not taught by the College of Management or specifically required by this curriculum.

Marketing Elective
Any marketing course taught by the College of Management.

College Approved Electives
Economics, management, or management science courses, not otherwise required, will satisfy this requirement. Courses taught by other Georgia Tech departments that will satisfy the College approved electives requirement are listed in the *Management Handbook*. College approved electives may not be taken on a pass/fail basis.

Bachelor of Science in Economics
Among the complex problems facing society today, economic issues stand in the forefront. In response to rapidly changing economic conditions, the public has become increasingly concerned with issues such as full employment, price stability, economic growth, adaptation to technological advances, efficiency in the management of complex industrial organizations, and international prosperity. The program in economics, based on the management core, enables students to analyze complex economic problems and to understand policies for their solutions.

Modern economics is analytically rigorous. The curriculum for this option prepares the student to cope with the advances that have been made in this field of study. The program requires a background in mathematics, statistics, and economic theory.

A degree in economics is suitable for students who wish to major in an academic discipline at the undergraduate level. Students also obtain professional management training through the elective courses in management. The degree in economics provides an excellent background for graduate work in economics, other social sciences, or management.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Science Electives	X-X-4	X-X-4	X-X-4
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2101, 2201, 2301, or 2401 Introduction to Literature or Drama and Film	.....	.....	3-0-3
Social Sciences Electives or Modern Languages Electives	3-0-3	3-0-3	3-0-3
Mathematics	5-0-5	5-0-5	5-0-5
Physical Education (requirements, p. 253)	.....	.....	X-X-3
Totals	X-X-15	X-X-15	X-X-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Engineering/Science/ Mathematics/ Architecture Electives	X-X-3	X-X-3	X-X-3
Literature Electives	3-0-3	3-0-3	3-0-3
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	.....
ECON 2000-1 Principles of Economics I, II	3-0-3	3-0-3	.....
ECON 3000 Economic Theory of the Firm	.....	.....	3-0-3
MSCI 2000 Management Applications of Data Processing	3-0-3	.....	.....
Social Sciences Elective or Modern Languages Elective	.....	.....	3-0-3
Free Electives	.....	3-0-3	3-0-3
TOTALS	X-X-15	X-X-15	X-X-15

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ECON 3001 National Income Analysis	3-0-3	.....	.....
ECON 3002 Money and Banking	.....	3-0-3	.....
MSCI 3110-1 Statistics I, II	3-0-3	3-0-3	.....
MSCI 3400 Analytical Methods in Management I	.....	.....	3-0-3
MGT 3150 Management Theory	3-0-3	.....	.....
MGT 3060-1 Finance I, II	3-0-3	3-0-3	.....
MGT 3300 Marketing I	3-0-3	.....	.....
Marketing Elective	.....	3-0-3	.....
MGT 4350 Production Management	.....	.....	3-0-3
ENGL 3015 Public Speaking	.....	3-0-3	.....
ECON 3100 Econometrics I	.....	.....	3-0-3
ECON 4000 Topics in Advanced Microeconomics	.....	.....	3-0-3

[MGT 4200]

	1st Q.	2nd Q.	3rd Q.
MGT 4200 Industrial Relations	.....	.....	3-0-3
TOTALS	15-0-15	15-0-15	15-0-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
MGT 3100, 4100, or 4110 Organizational Behavior Elective	3-0-3	.....	.....
Social Sciences Elective or Modern Languages Elective	.....	3-0-3	.....
Economics Electives	9-0-9	3-0-3	3-0-3
Free Electives	.....	6-0-6	9-0-9
ECON 4050 Monetary Theory and Policy	3-0-3	.....	.....
ECON 4400 History of Economic Thought	.....	3-0-3	.....
ECON 3095 Economic Policy	.....	.....	3-0-3
TOTALS	15-0-15	15-0-15	15-0-15

REQUIREMENTS
Mathematics
The mathematics requirement may be satisfied by one of the following sequences: MATH 1711-2-3; MATH 1307-8 and 1711; or MATH 1307-8-9 and 2307-8. Students may not register for MATH 1307 and 1712 or MATH 1308 and 1713. Courses must be taken and passed in sequence; concurrent registration for two or more of these courses is not permitted. Transfer students into the College must consult with the Management Office to determine their mathematics requirement at the time of transfer.

ELECTIVES
Science Electives
One year of science is required in chemistry, biology, or physics. Students must complete a series in one area.

Social Sciences Electives
All students must complete eighteen hours in the social sciences (see pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this re-

quirement and part of the total eighteen-hour requirement.

Psychology courses may be used to fulfill part of the eighteen hours in the social sciences (see pp. 41-42 for allowed courses).

Modern Languages Electives

Modern languages courses are encouraged by the College for students interested in international business. Although any level of modern languages courses may be taken, only certain courses on the 2000 level and higher may be applied to the eighteen-hour social sciences requirement (see pp. 41-42).

Physical Education Elective

No student may receive credit for more than three hours of physical education toward degree. See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements (page 253). The three-hour requirement can be fulfilled during any quarter of the freshman year.

Engineering/Science/Mathematics/Architecture Electives

One year is required of approved engineering courses, science, architecture, or advanced math not required by the core curriculum. Students should consult the *Economics Handbook* for restrictions.

Literature Electives

Students must complete nine hours of humanities selected from the English Department's programs in Drama and Film, American Literature, Literature and Science, and the Western Tradition in Literature and Art or from the Modern Languages Department's courses above the 2000 level that carry humanities credit, excluding linguistics.

Marketing Elective

Any course taught by the College of Management is appropriate. A course in marketing is suggested.

Economics Electives

Courses within the field of economics taught by the College of Management, unless approved by the curriculum committee of the College of Management.

Bachelor of Science in Management Science

Students who possess strength and interest in applying mathematics to managerial problems will benefit from the management science program at Georgia Tech. The program, based upon a foundation of applied mathematics and the institutional aspects of the modern business, develops analytic modes organized to allocate resources within the firm. The curriculum also contains a three-course sequence of specialization which permits the student either to concentrate in an applied area or to strengthen his or her theoretical foundation.

Graduates of the option will typically be employed as staff analysts in industry and government, as systems analysts, or in a wide variety of positions where a high degree of analytic ability is required. The program also provides a strong base for graduate study in business, economics, management science, operations research, information systems, and related areas.

For more detailed information, students should obtain the *Undergraduate Handbook for Management Science* available in the Office of Records, College of Management.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Science Electives	X-X-4	X-X-4	X-X-4
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2101, 2201, 2301, or 2401 Introduction to Literature or Drama and Film	.....	.....	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Social Sciences Electives or Modern Languages Electives	3-0-3	3-0-3	3-0-3
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TOTALS	X-X-15	X-X-15	X-X-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Literature Electives	3-0-3	3-0-3	3-0-3
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
ECON 2000-1 Principles of Economics I, II	3-0-3	3-0-3	.....
ECON 3000 Economic Theory of the Firm	.....	:.....	3-0-3
MSCI 2000 Management Applications of Data Processing	3-0-3	.....	.....
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	.....
MGT 3150 Management Theory	.....	.....	3-0-3
College Approved Electives	.....	1-0-1	6-0-6
TOTALS	17-0-17	15-0-15	15-0-15

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
MSCI 3200-1 Management Science I, II	3-0-3	3-0-3	.....
MATH 3215 Problems in Probability and Statistics	5-0-5	.....	.....
MATH 3716 Statistics for Management Science	.....	5-0-5	.....
MGT 4200 Industrial Relations	.....	.....	3-0-3
MGT 3100, 4100, or 4110 Organization Behavior Elective	3-0-3	.....	.....
MGT 3060 Finance	.....	.....	3-0-3
MGT 3300 Marketing I	.....	3-0-3	.....
ECON 3100 Econometrics	.....	.....	3-0-3
Marketing Elective	.....	.....	3-0-3
MGT 3070 Management Science Models in Finance	.....	3-0-3	.....
ENGL 3015 Public Speaking	.....	.....	3-0-3
MGT 4350 Production Management	3-0-3	.....	.....
TOTALS	14-0-14	14-0-14	15-0-15

Senior Year

Course	Credit Hours
Management Science Concentration Electives	9
Advanced Mathematics Electives	6
Specialization or Project Electives	9
Free Electives	18
MGT 4195 Integrated Management Problems	3
Total Senior Year	45

REQUIREMENTS

MSCI 3200-1, ECON 3100, and MATH 3716 are offered once a year only in quarters listed; thus they are to be taken as listed.

PREREQUISITES

MATH 3716 serves as the prerequisite for ECON 3100.

ELECTIVES
Science Electives

One year of science is required in chemistry, biology, or physics. Students must complete a series in one area.

Social Sciences Electives

Eighteen hours of electives in the social sciences are required of all students (see pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia; HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement and part of the total eighteen-hour requirement.

Psychology courses may be used to fulfill part of the eighteen hours in the social sciences (see pp. 41-42 for allowed courses).

Modern Languages Electives

Modern languages courses are encouraged by the College for students interested in international business. Although any level of modern languages courses may be taken, only certain courses on the 2000 level and higher may be applied to the eighteen-hour social sciences requirement (see pp. 41-42).

Physical Education Electives

No student may receive credit for more than three hours of physical education toward a degree. See "Curricula and Courses of Instruction," Department of Physical Educa-

tion and Recreation, p. 253, for freshman physical education requirements. The three-hour requirement can be fulfilled during any quarter of the freshman year.

Marketing Elective
Any marketing course taught by the College of Management.

Literature Electives
Students must complete nine hours of humanities selected from the English Department's programs in Drama and Film, American Literature, Literature and Science, and the Western Tradition in Literature and Art or from the Modern Languages Department's courses above the 2000 level that carry Humanities credit, excluding linguistics.

College Approved Electives
Seven hours are to be selected from courses taught by the College of Management and not used for other requirements of the MSCI curriculum. Additional nonmanagement courses have been approved, as listed in the *Management Science Handbook*.

Management Science Concentration Electives
Courses for the concentration in Management Science include MSCI 3300, 3400, 3401, 3402, 4801-2-3, 4811-2-3-4-5, ISYE 3010, 3233, 4005, 4006, 4044, 4145, and other courses (including graduate courses) throughout the Institute, as approved by your MSCI adviser. Please refer to page 47 regarding restrictions on undergraduates registering for graduate courses.

Advanced Mathematics Electives
Courses for advanced mathematics include MATH 2012, 2309, 3012, 3110, 3308, 3640, 4012, 4038, 4101, 4102, 4225, 4280, 4283, 4301, 4302, 4308, 4311, 4320, 4640, 4641, and other courses, as approved by your MSCI adviser.

Specialization Electives
For the specialization, the student selects an area of study and courses within that area. Areas of study include economics, finance, marketing, organizational behavior, psychology, accounting, management information systems, production/operations management,

computer science and other areas representing a consistent program of study in a minor area, as approved by your MSCI adviser. Related areas may be combined to yield programs such as economics/finance, finance/accounting, psychology/organizational behavior, marketing/finance, and management information systems/computer science.

Graduate Programs
The College of Management offers graduate programs leading to the Master of Science in Management (M.S.M.), the undesignated Master of Science, and the Doctor of Philosophy.

The M.S.M. program, which is accredited by the American Assembly of Collegiate Schools of Business, provides a professional management education for students with baccalaureate degrees in any discipline. Calculus is the only prerequisite. For students who want to review and sharpen their mathematical skills, a three-week, intensive review course is offered prior to the fall quarter.

The M.S.M. program comprises twenty-four courses (normally seventy-two hours), fifteen of which are required. These fifteen courses form a common core of knowledge required of all M.S.M. students. The remaining nine elective courses provide flexibility for students to build competence in one or more concentration areas. This freedom permits each student to fashion a curriculum directed toward individual educational and career goals. Available concentration areas include accounting, economics, finance, general management, management science, marketing, organizational behavior (including human resource management), and production and operations management.

Entry is in the fall quarter and the typical course load is four courses per quarter. Most of the common core is completed in the first academic year. Students with appropriate backgrounds are encouraged to substitute suitable advanced courses for some basic core requirements. Since summer course work is minimal, students are encouraged to participate in the College's internship program during the summer between the first

and second years of the program. Only three required courses are scheduled in the second year so that students can devote most of the year to concentration area(s) and electives.

The undesignated Master of Science degree program serves students whose educational and career goals may not be best served by the M.S.M. program. Under these circumstances, the student can pursue a master's level curriculum specifically designed for his or her individual needs. The student and an academic adviser determine the course requirements for such a curriculum. The Master's Committee of the College of Management must approve individually designed programs in advance.

The doctoral program in the College of Management complements and reflects the technological emphasis of the Institute.

All doctoral students take comprehensive examinations, which include both a general and a special examination. The student becomes a candidate for the degree after successful completion of both exams and the approval of the prospectus of his or her dissertation. On completion of the dissertation, the student must take a final oral examination as prescribed in the general regulations of the graduate division.

Program in Statistics
For information concerning the graduate program in statistics, refer to page 132.

Courses of Instruction
ECONOMICS

ECON 2000. Principles of Economics I
3-0-3. Prerequisite: sophomore standing.
The behavior of economic units in pricing and output decisions.

ECON 2001. Principles of Economics II
3-0-3. Prerequisite: sophomore standing.
Surveys national income, employment, money and banking, and international trade. Relates consumer, business, government, and international sectors to the aggregate economy.

ECON 3000. Economic Theory of the Firm
3-0-3. Prerequisites: ECON 2000-1.
Intermediate price theory with applications to management problems.

ECON 3001. National Income Analysis
3-0-3. Prerequisites: ECON 2000-1.
An intermediate macroeconomic theory course to enable the student to analyze the national economic

environment relative to the firm and stabilization of the national economy.

ECON 3002. Money and Banking
3-0-3. Prerequisites: ECON 2000-1.
An analysis of how money fits into the economic system and the problems of administering monetary policy both domestically and internationally.

ECON 3095. Seminar in Economic Policy
3-0-3. Prerequisites: ECON 3000-1.
Topics for discussion will be chosen to encourage the student to focus understanding of economic theory on a substantive problem. Designed for economics majors.

ECON 3100. Econometric Methods I
3-0-3. Prerequisite: MSCI 3111.
An introduction to the statistical methods for estimating the quantitative relationships among economic variables. Topics include model specification, parameter estimation, prediction, and verification.

ECON 3400. The Process of American Industrial Development
3-0-3. Prerequisites: ECON 2001-1.
The forces, unique characteristics, and problems associated with American industrialization.

ECON 3401. European Economic History
3-0-3. Prerequisites: ECON 2000-1.
An economic survey of the major institutions, inventions, the agricultural revolution, and the industrial revolution in Europe.

ECON 3410. Economic Development
3-0-3. Prerequisites: ECON 2000-1.
General theories of economic development. Each student will be required to analyze the economy of a developing country.

ECON 3500. Scope and Method of Political Economy
3-0-3. Prerequisites: ECON 2000-1.
The logical structure of scientific theory as it applies to knowledge about political and economic situations and events.

ECON 3501. Political Economy: Public Policy Analysis I
3-0-3. Prerequisites: ECON 2000-1.
A theoretical perspective to explain and predict the effects of actual and proposed public policy and to generate some standards of evaluation.

ECON 4000. Topics in Advanced Microeconomics
3-0-3. Prerequisites: ECON 3000-1.
Selected topics in advanced microeconomics. Designed for economics majors.

ECON 4050. Monetary Theory and Policy
3-0-3. Prerequisite: ECON 3001.
The behavior of interest rates, the structure of financial markets, aspects of various financial institutions, and issues in monetary policy.

ECON 4110. Mathematical Economics
3-0-3. Prerequisites: ECON 2000-1.
Emphasizes the application of mathematical tools to economic analysis. Topics include static analysis, comparative-static analysis, optimization, and dynamic analysis.

ECON 4120. Economic Forecasting
3-0-3. Prerequisites: ECON 2000-1.
Cyclical fluctuations in the total economy are examined empirically. Methods of making forecasts of national and industry performance are presented.

ECON 4230. Economics of the Labor Market
3-0-3.
The application of microeconomic theory to wages, employment, and productivity.

ECON 4231. Labor History
3-0-3.
A survey of the times and conditions facing the working class in attempting to establish a body of industrial jurisprudence.

ECON 4235. Protective Labor Legislation
3-0-3.
Federal and state regulation of worker security against occupational injury, unemployment, old age, disability and discrimination, plus wage and hour legislation.

ECON 4265. Labor Relations Law
3-0-3. Prerequisite: MGT 4200.
An examination of labor legislation, court decisions, and NLRB rulings on labor-management relations.

ECON 4300. International Economics
3-0-3. Prerequisites: ECON 2000-1.
Foreign trade and commercial policy, international finance, and current problems of international economic relations.

ECON 4310. Public Finance
3-0-3. Prerequisite: ECON 3000.
Analyzes government's role in resource allocation, income distribution, stabilization and growth through the economic effects of government spending and revenue-raising activities.

ECON 4320. Managerial Economics
3-0-3. Prerequisite: ECON 3000.
Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial decisions.

ECON 4330. Regional Economics
3-0-3. Prerequisites: ECON 2000-1.
Theories of regional income determination and regional growth, spatial economic structure, central-place theory, and regional effects of public policy.

ECON 4331. Urban Economics
3-0-3. Prerequisites: ECON 2000-1.
The economic dimensions of the processes and problems associated with urbanization.

ECON 4332. Economics of Industrial Location
3-0-3. Prerequisite: ECON 3000.
A survey of economic factors influencing industrial location. Consideration will be given to location patterns, the impact of transfer processing costs, and land use competition.

ECON 4340. Economics of Industrial Competition
3-0-3. Prerequisites: ECON 2000-1.
The competitive structure of the American economy in terms of economic models, alternative public policy goals, and the development of antitrust laws.

ECON 4341. Economics of Regulated Industries
3-0-3. Prerequisites: ECON 2000-1.
The problems and policy options associated with government regulation of particular industries.

ECON 4400. History of Economic Thought
3-0-3. Prerequisites: ECON 2000-1.
A historical survey of schools of economic thought. The main body of the course is concerned with classical, neoclassical, Marxist, Keynesian, and modern economic thought.

ECON 4410. Industrial Development in Latin America
3-0-3. Prerequisites: ECON 2000-1.
The principles of industrial development in emerging nations. The student prepares an analysis of the problems in a specific Latin American country.

ECON 4420. Comparative Economic Systems
3-0-3. Prerequisites: ECON 2000-1.
A critical study of the methods by which various economic systems meet common fundamental problems in production, exchange, distribution, and capital formation.

ECON 4500. Political Economy: Nonmarket Decision Making I
3-0-3. Prerequisites: ECON 2000-1.
Collective choice through an economic-rational choice perspective, seeking to explain and predict the relationships among campaigns, voting, and public policy toward private enterprise.

ECON 4501. Political Economy: Nonmarket Decision Processes II
3-0-3.
The economics and politics of change, technological progress, price effects on innovation, and trade-offs between economic efficiency and political expediency in national policies for energy, research, etc.

ECON 4801-2-3. Special Topics in Economics
3-0-3 each.
A course designed to permit students to pursue a specialized interest in an area of economics not extensively treated in the offerings of the College.

ECON 4811-2-3-4-5. Special Topics in Economics
1-0-1 through 5-0-5 respectively.
Courses designed to permit students and a professor to pursue a specialized interest in an area of economics not extensively treated in the offerings of the College.

ECON 4901-2-3. Individual Research in Economics
Credit to be arranged.
Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the dean's representative and of the sponsoring professor.

ECON 4990. Georgia Internship Program
Credit to be arranged. Prerequisite: consent of the College.
Broadens the scope of the college curriculum by offering students a community-based learning experience that stresses the completion of a specific task.

ECON 6000. Economic Analysis for Management I
3-0-3. Prerequisite: consent of the College.

An intensive treatment of economic concepts that enables the prospective manager to understand the economic environment within which firms operate.

ECON 6001. Economic Analysis for Management II
3-0-3. Prerequisite: consent of the College.
Topics in economic analysis oriented to provide a framework for contemporary management.

ECON 6005. Cost-Benefit Analysis
3-0-3. Prerequisite: ECON 6000.
Methods for public project evaluation, including decision criteria, identifying and quantifying costs and benefits, sensitivity analysis, and procedures for performing a cost-benefit analysis.

ECON 6050. Money and Capital Markets
3-0-3. Prerequisite: ECON 6000.
The functions of and relationships between various financial markets and institutions, the behavior of interest rates, and the impact of monetary policy on financial markets.

ECON 6120. Economic Forecasting
3-0-3. Prerequisite: ECON 6001.
Macroeconomic theory and the analysis of overall economic conditions with their application to management problems of the industrial firm.

ECON 6230. Collective Bargaining
3-0-3. Prerequisite: previous course in labor relations.
Case course involving contract negotiations, grievance handling, and arbitration.

ECON 6266. Wage and Employment Theory
3-0-3. Prerequisites: ECON 6000, 6001.
An analysis of the economic theories and institutional developments explaining the terms, conditions, and levels of employment.

ECON 6300. International Trade and Finance
3-0-3. Prerequisite: ECON 6001.
Foreign exchange market, foreign trade and commercial policy, international finance and current problems of international economics.

ECON 6320. Managerial Economics
3-0-3. Prerequisite: ECON 6000.
Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial problems, and the determinants of good managerial decisions.

ECON 6330. Regional Economics
3-0-3.
Survey of the economics of regions, emphasizing region delineation, systems of cities, measurement of regional activity, theories of income, employment, and economic growth.

ECON 6331. Economics of Industrialization
3-0-3.
An examination of long-run growth processes seeking causes of underdevelopment, exploring theories of economic growth, and applying these explanations to developed and underdeveloped economies.

ECON 6335. The Economics of Environmental Quality
3-0-3. Prerequisite: consent of the College.

Topics include the causes of market failure to provide a high-quality environment, amenity resources, and extra-market values.

ECON 6340. Industry and Government
3-0-3. Prerequisite: ECON 6000.
Organization and the structure of American industry, beginning with price theory under various forms of market structure.

ECON 6400. Public Issues in Economic Policy
3-0-3.
Major public issues from the viewpoint of American economic history.

ECON 6410. Development of Economic Thought
3-0-3. Prerequisites: ECON 6000-1, consent of the College.
Development of the various schools of economic thought and their contributions to the present body of economic theories. Credit not given for both ECON 4400 and 6410.

ECON 6750. The Changing Economy
3-0-3.
This course examines the long-run forces within the economy that support economic growth and rising standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

ECON 6760. Financial Management and Economics of Nuclear Power
3-0-3.
Interdisciplinary relationship of the nuclear fuel cycle and reactor system to the electrical power industry treated as a system, effect of management decisions on the overall economics. Also listed as NE 6760.

ECON 7000. Master's Thesis

ECON 7010. Advanced Microeconomic Analysis
3-0-3. Prerequisite: consent of the College.
An analysis of consumer and firm decision making in order to facilitate model building of individual choice processes.

ECON 7011. Seminar in Microeconomics
3-0-3. Prerequisite: consent of the College.
Interrelationships among the major aggregated sectors of a national economy taking special cognizance of institutions that exist in the United States.

ECON 7020. Advanced Macroeconomic Analysis
3-0-3. Prerequisites: ECON 7010 and consent of the College.
Students have an opportunity to pursue in depth some topic or problem in the area of macroeconomics.

ECON 7021. Seminar in Macroeconomics
3-0-3. Prerequisites: ECON 7011 and consent of the College.
Students have an opportunity to pursue in depth some topic in the area of macroeconomics.

ECON 7100. Econometrics
3-0-3. Prerequisite: consent of the College.
Advanced treatment of the specification, estimation, forecasting, and policy evaluation of both static and dynamic managerial models. Techniques, applications, and problems associated with both single equation and simultaneous equation models are included.

ECON 7101. Seminar in Econometrics
3-0-3. Prerequisites: ECON 7100 and consent of the College
Empirical economic research.

ECON 8401-2-3-4-5-6. Special Topics
1-0-1 through 6-0-6. Prerequisite: consent of the College.
Topics of current interest in the field of economics.

ECON 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the College.
Provides project work experience in the field of economics.

ECON 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate teaching assistantships.

ECON 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate research assistantships.

ECON 9000. Doctoral Thesis

MANAGEMENT

MGT 2000. Accounting I
3-0-3. Prerequisite: sophomore standing.
Provides a general understanding of financial accounting systems and an interpretation of financial reports.

MGT 2001. Accounting II
3-0-3. Prerequisite: MGT 2000.
Provides a general understanding of cost accounting systems with emphasis on the manufacturing situation.

MGT 2002. Accounting III
3-0-3. Prerequisite: MGT 2001.
Provides a general understanding of management applications of accounting output in a decision context.

MGT 2010. Honors Financial Accounting
3-0-3.
A more intensive and rigorous treatment of topics covered in MGT 2000. Credit is not allowed for both MGT 2000 and MGT 2010.

MGT 2011. Honors Cost Accounting
3-0-3.
A more intensive and rigorous treatment of topics covered in MGT 2001. Credit is not allowed for both MGT 2001 and MGT 2011.

MGT 2012. Honors Managerial Accounting
3-0-3.
A more intensive and rigorous treatment of topics covered in MGT 2002. Credit is not allowed for both MGT 2002 and MGT 2012.

MGT 3010. Taxation
3-0-3. Prerequisite: MGT 2000.
Business income tax requirements and the management planning necessitated by various tax alternatives. Some attention to personal income taxes.

MGT 3020. Accounting Theory and the Analysis and Interpretation of Financial Statements
4-0-4. Prerequisite: MGT 2002.
Accounting techniques and principles for measuring assets, equities, and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, accounting theory, etc.

MGT 3021. Topics in Managerial Accounting and Control
3-0-3. Prerequisites: MGT 2002 and MSCI 3100.
Advanced topics in managerial reporting and analysis, such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control, and other issues in internal resource allocation.

MGT 3050. Computer-based Management Systems
3-0-3. Prerequisite: MSCI 2000.
An introduction to concepts used in the design of management systems relying on computers and information technology.

MGT 3060. Finance I
3-0-3. Prerequisites: ECON 2000, MGT 2001, and MSCI 3100 or an equivalent statistics course.
Introduction to financial analysis, financial planning, and working capital management.

MGT 3061. Finance II
3-0-3. Prerequisite: MGT 3060.
Application of capital budgeting techniques to the firm, including selection from alternative investment opportunities, determining cost of capital, and treatment of uncertainty.

MGT 3065. Topics in Financial Analysis
3-0-3.
Subjects covered include cross sectional and time series, analysis of financial statements, advanced topics in capital asset pricing, predicting systematic risk, predicting and analyzing bankruptcies, mergers, and acquisitions.

MGT 3070. Management Science Models in Finance
3-0-3. Prerequisite: MGT 3060.
A study of the analytical techniques in finance, including capital budgeting, portfolio theory, and capital market theory.

MGT 3080. Investments
3-0-3. Prerequisite: MGT 3060.
The theory and practice of security analysis and portfolio management as applied to stocks and bonds.

MGT 3090. Commercial Bank Management
3-0-3. Prerequisite: MGT 3060 or permission of the instructor.
Contemporary problems and practices of managing banks and related institutions, including asset and liability management, loan and liquidity management, and aspects of regulation.

MGT 3100. Organizational Development
3-0-3.
Analysis of the structural development of the organization. Particular emphasis is given to organization-environment interfaces, effectiveness, and efficiency. Managing technology and change.

MGT 3150. Management Theory
3-0-3. Prerequisites: MGT 2002, ECON 2000 and 2001.

Provides students with a fundamental management theory matrix essential to the understanding of management, process, and role.

MGT 3161. Management as a Creative Force
3-0-3.
Describes the manager's role in accomplishing the entrepreneurial mission of the enterprise. Each student analyzes the reports on an existing organization.

MGT 3260. Business Law I
3-0-3.
Development and function of the law, court organization, procedure and substantive law in contracts, business organizations, and agencies.

MGT 3261. Business Law II
3-0-3.
Legal problems encountered in an urban environment with a socioeconomic and political atmosphere, specifically in the areas of consumer problems, bankruptcy, and constitutional law.

MGT 3300. Marketing I
3-0-3. Prerequisite: ECON 2000.
Marketing's role in productive process, basic buyer behavior, market segmentation concepts, the management of marketing activities, environmental influences on marketing management.

MGT 3301. Marketing Management
3-0-3. Prerequisite: MGT 3300.
Emphasis on marketing management problems through the process of analysis, planning and control, case analysis, and readings.

MGT 3310. Marketing Research
3-0-3. Prerequisites: MGT 3300, MSCI 3100.
Research orientation, planning an investigation, questionnaires, sampling, interpretation of results, report presentation.

MGT 3320. Management Science Models in Marketing
3-0-3. Prerequisites: MGT 3300 and MSCI 2000, 3100, 3400.
The use of management science models to solve marketing management problems; application rather than theory is stressed.

MGT 3330. Contemporary Issues in Marketing
3-0-3. Prerequisite: MGT 3300.
Course is designed to encourage students to examine the principles of marketing in light of contemporary thinking concerning social, economic, and technological development.

MGT 3700. Analysis of Financial Data
4-0-4. Not open to College of Management undergraduates.
A survey of general and cost systems. Emphasis on the use of accounting data. Credit not given for MGT 3700 and any other undergraduate accounting course.

MGT 4020. Auditing and Accounting Systems
3-0-3. Prerequisites: MGT 2001, 3060.
Emphasizes both the design of accounting systems and external and internal auditing and control procedures.

MGT 4022. Problems in Financial Reporting
4-0-4. Prerequisite: MGT 3020.

Consolidations, funds statements, earnings per share, results of operations, mergers and poolings, general price level adjustments, foreign exchange transactions, and not-for-profit organizations.

MGT 4024. Seminar in Financial Reporting and Control
4-0-4. Prerequisite: MGT 4022.
In-depth study of one or two major current issues in accounting involving controversy and a significant possibility of substantial impact on theory and practice.

MGT 4040. Auditing Concepts
4-0-4. Prerequisites: MSCI 3100 and MGT 3020.
Problems in certifying financial statements, including audit objectives, statistical approaches to audit scope, and auditing complex computerized data systems.

MGT 4100. Organizational Analysis
3-0-3.
Analysis of internal outcomes of the organizing process. The individual-organization interface is studied to understand perception, motivation, group formation, and leadership within the firm.

MGT 4110. The Management of Organized Effort
3-0-3. Open only to seniors.
Management as a process of developing and controlling situations toward which people act and respond, both individually and as members of groups.

MGT 4115. Contemporary Management Thought
3-0-3. Prerequisite: MGT 3150 or consent of the College.
This course emphasizes the impact of changing social values on management thought and practices. Guest speakers make important contributions to the course.

MGT 4120. Contemporary Research in Management
3-0-3. Prerequisite: either MGT 3100, 4100, or consent of the College.
Investigations, analyses, critiques, and reports of current research orientations in management. Students learn how management research is done.

MGT 4140. Personnel Management Problems
3-0-3. Prerequisite: MGT 3150 or consent of the College.
Analysis of the personnel management process, with emphasis placed upon the role and contribution to the firm of the staff function of personnel administration.

MGT 4151. Management of Industrial Research and Development Programs
3-0-3. Normally taken by seniors.
Analysis of managerial considerations involved in conducting industrial basic and applied research programs and their integration with marketing, manufacturing, and finance activities of the firm.

MGT 4155. Fundamentals of World Business
3-0-3. Prerequisites: MGT 2001, 3150.
Covers the broad aspects of international business, position of the United States in world markets, various types of international business transactions, and the relationship of business to economics, politics, culture, and government interaction.

MGT 4160. Management Concepts and Issues in World Business
3-0-3. Normally taken by seniors.

Covers significant aspects of international business, changing patterns of world industry, emergence of common markets, role of United States industry overseas.

MGT 4165. Seminar
1-0-1. Prerequisits: junior standing.
Lectures and discussions with prominent business, government, labor, and educational leaders. Offered winter quarter only.

MGT 4170. Career Analysis
3-0-3. Prerequisite: seniors standing.
A course designed to enable students to analyze classified jobs in a company to determine career paths, training provided, and counseling for workers.

MGT 4180. Industrial Management Honors Seminar
3-0-3. Last or next to last quarter seniors by faculty invitation.
Gives outstanding seniors an opportunity to research, analyze, and discuss current management and economic problems.

MGT 4195. Integrated Management Problems
3-0-3. Prerequisites: senior standing and MGT 3150, 3300, a marketing elective, MGT 3061 or 3070, and 4350.
Comprehensive cases are used to integrate knowledge at the policy level of management and to relate managerial decisions to the economic and competitive forces affecting business.

MGT 4200. Industrial Relations
3-0-3.
Theories of the labor movement, union-management relationship, including the legal setting, contract negotiations, contract administration, and the roles and nature of third parties.

MGT 4201. Contemporary Unionism and Collective Bargaining
3-0-3. Prerequisite: MGT 4200.
A study of union structure, collective bargaining procedures, and the analysis of union-management contracts.

MGT 4202. Cases in Labor-Management Relations
3-0-3. Prerequisite: MGT 4200.
A case study of problem areas in union-management relations. The cases used will be actual (NLRB) and labor arbitration decisions.

MGT 4250. Nonmarket Environment of the Firm
3-0-3. Open only to seniors.
An examination of the sociocultural factors that must be taken into account in the management decision process and of the forces that lead to their change through time.

MGT 4290. Public Administration
3-0-3.
An examination of the managerial function of federal, state, and local governments, with emphasis on the role of their interaction with the private sector.

MGT 4331. Consumer Behavior
3-0-3. Prerequisite: MGT 3300.
Stresses the impact of buyer decisions on the firm's marketing functions. Discusses economic, psychological, sociological, anthropological, and organization impacts on buyer decisions.

MGT 4335. International Marketing
3-0-3. Prerequisite: MGT 3300.
Emphasis on international comparative analysis, the role of marketing in economic development, and marketing strategies and policies of multinational firms.

MGT 4350. Production Management
3-0-3. Prerequisites: MGT 3150, MSCI 3400.
The organizational, economic, and physical setting in which production occurs. Methods to analyze and improve production processes and service operations.

MGT 4801-2-3. Special Topics in Industrial Management
3-0-3 each.
Permits groups of students and a professor to pursue areas of management not extensively treated in other courses.

MGT 4811-2-3-4-5. Special Topics in Management
1-0-1 through 5-0-5 respectively.
Permits a group of students and a professor to pursue areas of management not extensively treated in other courses of the college.

MGT 4901-2-3. Individual Research in Industrial Management
Credit to be arranged.
Designed to permit independent study with a faculty member. To register, the student must obtain the written approval of the dean's representative and of the sponsoring professor.

MGT 4990. Georgia Internship Program
Credit to be arranged. Prerequisite: consent of the College.
Broadens the scope of the college curriculum by offering students a community-based learning experience that stresses the completion of a specific task.

MGT 6000. Financial Accounting
3-0-3. Prerequisite: consent of the College.
A foundation course in measuring and reporting the financial performance and status of the firm. Emphasizes underlying theoretical concepts, reporting requirements, and financial analysis implications of modern financial accounting.

MGT 6001. Managerial Accounting
3-0-3. Prerequisite: MGT 6000 and consent of the College.
Introduction to cost and managerial accounting. Topics include basic cost concepts, costing systems, cost-volume-profit analysis, and the general role of accounting data in planning, control, and decision making.

MGT 6020. Accounting Theory and the Analysis and Interpretation of Financial Statements
4-0-4. Prerequisite: MGT 6000.
Accounting techniques and principles of measuring assets, equities and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, accounting theory, etc.

MGT 6021. Topics in Managerial Accounting and Control
3-0-3. Prerequisites: MGT 6001 and consent of the College.

Advanced topics in managerial reporting and analysis, such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control, and other issues in internal resource allocation.

MGT 6022. Financial Reporting
4-0-4. Prerequisite: MGT 6020.
Consolidations, funds statements, earnings per share, results of operations, mergers and poolings, general price level adjustments, foreign exchange transactions, and not-for-profit organizations.

MGT 6023. Behavioral Aspects of Control
3-0-3. Prerequisites: MGT 6001, 6100.
The relationship between planning, budgeting, and control processes in complex organizations and their interaction with organization structure, managerial behavior, information systems, and financial performance.

MGT 6024. Financial Reporting and Control
4-0-4. Prerequisite: MGT 6022.
In-depth study of one or two major current issues in accounting, involving controversy and a significant possibility of substantial impact on theory and practice.

MGT 6025. Socioeconomic Accounting
4-0-4. Prerequisite: MGT 6001.
Use and limitations of accounting analysis in defining and measuring the economic costs, benefits, and effectiveness of public projects and not-for-profit organizations.

MGT 6040. Auditing Concepts
4-0-4. Prerequisite: MGT 6001.
Problems in certifying financial statements, including audit objectives, statistical approaches to audit scope, and auditing complex computerized data systems.

MGT 6041. Taxation and Decisions
4-0-4. Prerequisites: ECON 6000, 6001, and MGT 6000, or consent of the College.
A comprehensive examination of the major provisions of the Internal Revenue Code. Emphasis is placed upon the impact of taxes on business decisions.

MGT 6060. Financial Management I
3-0-3. Prerequisites: graduate standing and MSCI 6020. Corequisite: MGT 6001.
Modern finance emphasizing concepts useful to the nonfinancial manager. Financial statement analysis, financial projections and forecasting, time value, cost of capital, capital budgeting, risk and valuation.

MGT 6061. Financial Management II
3-0-3. Prerequisites: MGT 6060, MSCI 6021.
Financial structure, dividend policy, financial instruments, debt maturity structure, introduction to portfolio theory, asset pricing, marketing efficiency, capital markets, investment banking, banking, financial institutions, and working capital.

MGT 6062. Theory of Financial Management
3-0-3. Prerequisite: MGT 6061.
Financial policy, theory, and cases dealing with a variety of topics in corporate finance.

MGT 6063. Corporate Cash Management and Banking Relations
3-0-3. Prerequisites: MGT 6061, MSCI 6022.
Daily cash management, short-term securities, cash planning, cash forecasting, credit lines, short-term financ-

ing, banking relations, collection systems, credit policy, and other aspects of the corporate treasurer's job.

MGT 6064. Financial Planning Systems
3-0-3. Prerequisites: MGT 6063, MSCI 6055.
Computer-based financial statement generators and budgeting systems, short- and long-term financial models, computer-based capital budgeting systems, and a variety of other financial planning models.

MGT 6065. Seminar in Financial Management
3-0-3. Prerequisite: MGT 6061.
Topics of current interest in the field of financial management.

MGT 6080. Investments I
3-0-3. Prerequisite: MGT 6060.
The theory and practice of security analysis and portfolio management as applied to stocks and bonds.

MGT 6081. Investments II
3-0-3. Prerequisite: MGT 6080.
A continuation of MGT 6080. Includes advanced topics in portfolio theory and detailed study of bonds, options, and futures contracts.

MGT 6090. Commercial Bank Management
3-0-3. Prerequisite: MGT 6060 or permission of the instructor.
The analysis of management problems of commercial banks, including the loan, investment, deposit, and capital functions and the interrelationships between them.

MGT 6100. Organization Processes
3-0-3. Prerequisite: consent of the College.
Introduction to behavioral issues in individual, group, and organizational performance.

MGT 6101. Contemporary Issues in Human Resource Management
3-0-3. Prerequisite: consent of the College.
Survey of the manager's role in understanding and implementing an organization's human resource policy.

MGT 6102. Methodology in Human Resource Management
3-0-3. Prerequisite: MGT 6101.
The use of statistics and methodology in making data-based decisions about human resources.

MGT 6103. Compensation and Jobs
3-0-3. Prerequisite: MGT 6101.
Concepts and procedures used for compensating managerial and nonmanagerial personnel.

MGT 6104. Attraction, Selection, and Development of Human Resources
3-0-3. Prerequisite: MGT 6101.
Advanced study of legal, statistical, and theoretical issues in the development of effective human resource policies.

MGT 6105. Individuals in Organizations
3-0-3. Prerequisite: MGT 6100.
Discussion and application of theories involving individual behavior in organizations.

MGT 6106. Group Processes in Organizations
3-0-3. Prerequisite: MGT 6100.
Problems in understanding and managing the performance of work groups.

MGT 6107. Organization Theory
3-0-3. Prerequisite: MGT 6100.
A treatment of factors affecting the design of effective complex organizations.

MGT 6108. Human Resource Management Practicum
3-0-3. Prerequisite: MGT 6101.
Experiences in dealing with and solving various human resource management problems.

MGT 6140. Management Systems Analysis
3-0-3.
An analysis of the environmental factors and forces that interact to form systems and their resultant impact upon the practice of management.

MGT 6155. Development of Management Thought
3-0-3.
A survey of the development of management thought based upon a critical examination of classic works in management literature.

MGT 6160. Management Theory
3-0-3. Prerequisite: consent of the College.
Provides resources essential to the development of a matrix of management theory at the professional level.

MGT 6175. Entrepreneurial Management
3-0-3. Prerequisite: MGT 6000.
The manager's role in building or restructuring enterprises. Students interact with entrepreneurs in and out of class and write a report on a growing firm.

MGT 6180. Multinational Business
3-0-3. Prerequisite: consent of the College.
Critical examination of business concepts, organizational structures, and control processes of the multinational corporation in different political and economic environments.

MGT 6195. Managerial Policy I
3-0-3. Prerequisites: MGT 6000, 6100, ECON 6000, and two of MGT 6001, 6060, 6300, 6350.
Economic, competitive, and governmental forces affecting the formulation of corporate strategy and managerial policies and decision making.

MGT 6196. Managerial Policy II
3-0-3.
An examination of selected strategic issues, problems, and competitive strategies in particular industries and types of organizations, combined with field projects and guest lectures.

MGT 6200. Labor Problems
3-0-3.
An examination of the union-management relationship. Includes analysis of labor agreement, grievance procedures and arbitration, and the legal environment of labor relations.

MGT 6260. The Legal Environment
3-0-3.
The role of law in society, legal philosophy, and basic legal concepts.

MGT 6300. Marketing Management I
3-0-3.

Critical analysis of the marketing functions of an industrial enterprise, organizing and control of marketing programs is emphasized.

MGT 6301. Marketing Management II
3-0-3. Prerequisite: MGT 6300.
Advanced course in marketing analysis and strategy formulation. Particular emphasis will be given to application of materials from MGT 6300.

MGT 6302. Buyer Behavior
3-0-3. Prerequisite: MGT 6300.
This course exposes students to behavioral science concepts and approaches of relevance in describing, understanding, and predicting the behavior of consumers.

MGT 6303. Sales and Promotion Management
3-0-3. Prerequisites: MGT 6300, 6301.
Advertising, personal selling, sales promotion aids, channel (resellers) stimulation, and other communication tools as variables in the overall promotional mix.

MGT 6305. Strategic Market Planning
3-0-3. Prerequisites: MGT 6300, 6301.
Integrates marketing planning into the strategic planning process. Focuses on new concepts and techniques that facilitate market analysis and the development of strategic plans.

MGT 6310. Marketing Research and Analysis
3-0-3. Prerequisite: MGT 6300.
Theory and techniques of marketing analysis and its use in the formulation of policy and strategy.

MGT 6315. Marketing Analysis
3-0-3. Prerequisites: MGT 6300, 6310.
This course seeks to impart an understanding of the various techniques useful for analyzing and interpreting marketing research data.

MGT 6320. Marketing Models
3-0-3. Prerequisites: MGT 6300 and a knowledge of probability and statistics.
Marketing models utilizing probability and statistics as well as behavioral techniques.

MGT 6330. Consumerism and Public Policy Issues in Marketing
3-0-3. Corequisite: MGT 6300.
Recent issues in consumerism, the performance of marketing activity within our society.

MGT 6350. Production and Operations Management I
3-0-3. Prerequisite: MSCI 6020 or equivalent. Corequisite: MSCI 6022 or equivalent.
Processes and management of production of goods and services. Methods to analyze, improve, and plan production. Case studies.

MGT 6351. Production and Operations Management II
3-0-3. Prerequisite: MGT 6350.
Continuation of MGT 6350, with more emphasis on computer models.

MGT 6750. The Changing Economy
3-0-3.
This course examines the long-run forces within the economy that support economic growth and rising

standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

MGT 7000. Master's Thesis

MGT 7750. Seminar on Psychology and Management
3-0-3. Prerequisites: PSY 6601 or 6609, MGT 6150 or 6105, and consent of the College.
Selected management problems involving psychological complexities, individual behavior in an organizational setting. Also listed as PSY 7750.

MGT 8401-2-3-4-5-6. Special Topics
1-0-1 through 6-0-6 respectively. Prerequisite: consent of the College.
Topics of current interest in the field of management.

MGT 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the College.
Provides project work experience in the field of management.

MGT 8801-2-3-4. Management Research
Credit to be arranged.
Credit given for the presentation of a satisfactory written report embodying the results of intensive research and study of a management problem. Conferences will be arranged.

MGT 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

MGT 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

MGT 9000. Doctoral Thesis

MANAGEMENT SCIENCE

MSCI 2000. Management Applications of Data Processing
2-3-3.
Provides a technical foundation for the development of computer-based management systems.

MSCI 3100. Survey of Statistics
3-0-3. Prerequisite: MATH 1711.
A survey of discrete probability and statistics with emphasis on economic and business applications. Serves as core requirement for MGT degree. Credit cannot be obtained for MSCI 3100 and either or both MSCI 3110 and 3111.

MSCI 3110. Statistics I
3-0-3. Prerequisites: MATH 1713, 1711.
Emphasis on continuous probability models and discrete models. Required of economics majors and recommended to those wanting a two-course sequence in statistics. Credit cannot be obtained for MSCI 3110 and 3100.

MSCI 3111. Statistics II
3-0-3. Prerequisites: MATH 1713, 1711.

Classical inference and estimation, drawing heavily on calculus for topics such as maximum likelihood estimation, evaluation of decision rules, etc. Credit cannot be obtained for both MSCI 3111 and MSCI 3100.

MSCI 3200. Management Science I
3-0-3. Prerequisite: matrix algebra.
Applications of linear programming to the analysis of managerial problems. Topics include duality, transportation problems, and postoptimality analysis.

MSCI 3201. Management Science II
3-0-3. Prerequisite: MATH 3215.
This second course in the methodology and application of management science is concerned with the use of stochastic models in the analysis of managerial and economic decision making.

MSCI 3300. Decision Analysis in Management
3-0-3. Prerequisite: MATH 1711.
An introduction to decision models for management situations under risk and uncertainty, including fundamental economic concepts of a theory of rational choice.

MSCI 3400. Analytical Methods in Management I
3-0-3. Prerequisite: MATH 1711.
Introduction to linear programming. Emphasis on formulation of problems encountered in professional practice and on interpretation of solutions.

MSCI 3401. Analytical Methods in Management II
3-0-3. Prerequisite: MSCI 3400 or 3200.
Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

MSCI 3402. Analytical Methods in Management III
3-0-3. Prerequisite: MSCI 3400 or 3200.
Introduction to the theory and applications of dynamic, integer, and nonlinear programming in the analysis of management decision problems.

MSCI 3403. Analytical Methods in Management IV
3-0-3. Prerequisite: MSCI 3100 or 3110.
Analytical and simulation approaches to the analysis of queueing and inventory systems.

MSCI 4801-2-3. Special Topics in Management Science
3-0-3 each. Normally taken by seniors.
Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the College.

MSCI 4811-2-3-4-5. Special Topics in Management Science
1-0-1 through 5-0-5 respectively.
Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the College.

MSCI 4990. Georgia Internship Program
Credit to be arranged. Prerequisite: consent of the College.
Broadens the scope of the College curriculum by offering students a community-based learning experience that stresses the completion of a specific task.

MSCI 4991-2-3. Special Problems
Credit to be arranged.
The special project is designed to provide the student an opportunity to apply his or her full training to the analysis of an applied or theoretical problem. To register, the student must obtain the written approval of the dean's representative and of the sponsoring professor.

MSCI 6010. Analytical Methods in Management
3-0-3.
Introduction to matrix algebra and calculus. Emphasis on formulating and solving problems in management and economics.

MSCI 6020. Quantitative Methods for Management I
3-0-3. Prerequisite: MSCI 6010 or its equivalent.
This first of three core courses focuses on probability and its uses to structure decision problems.

MSCI 6021. Quantitative Methods for Management II
3-0-3. Prerequisite: MSCI 6020 or its equivalent.
This second of three core courses includes inferential statistics and decision analysis. Topics include hypothesis tests, forecasting, regression, Bayesian methods, utility theory, and simulation.

MSCI 6022. Quantitative Decision Procedures
3-0-3.
This third of three core courses introduces formal analysis of management and economic decision problems through the use of optimization methods. Includes linear programming and mixed integer programming.

MSCI 6023. Cases and Applications in Management Science
3-0-3. Prerequisites: MSCI 6021, 6022.
Application of management science in varied functional and organizational contexts. Actual cases are analyzed, and the results are communicated in oral and written reports.

MSCI 6051. Computer Simulation of Management Problems
3-0-3. Prerequisite: MSCI 6021 or equivalent.
Techniques of simulating general management decisions utilizing information from the areas of marketing, production, finance, and industrial relations.

MSCI 6055. Management Information Systems
2-2-3. Prerequisites: MSCI 6020, 6021 or equivalent.
Introduction to computer-based information systems technology and its application to support managerial decisions.

MSCI 6101. Applications of Statistical Methods to Management Decision Making
3-0-3. Prerequisite: MSCI 6021 or equivalent.
Theory and applications of elementary multiple regression analysis in a management framework.

MSCI 6102. Applications of Regression Analysis for Management
3-0-3. Prerequisite: MSCI 6101.
Multivariate statistical analysis with applications in business economics.

MSCI 6105. General Decision Theory
3-0-3. Prerequisite: MSCI 6020.
Models of nondeterministic decision situations. General finite games in extensive and normal forms, utility

indicators, matrix games, mixed extensions, the fundamental theorem, and computational techniques.

MSCI 6106. Applications of General Decision Theory in Management and Economics
3-0-3. Prerequisite: MSCI 6020.
Risk games, statistical games, Bayes and min-max strategies, principle of choice problem, no data and data variants. Applications in management and economics.

MSCI 6201. Stochastic Optimization
3-0-3. Prerequisite: MATH 4221 or MSCI/MATH 6750.
Optimization of sequential decision models for production, congestion, inventory, fisheries, and other contexts. Myopic policies, Markov decision processes, and monotone policies.

MSCI 6300. Risk Management
3-0-3. Prerequisites: probability and statistics at the level of MSCI 6020 and 6021.
Scope and methods of risk management. Protecting the firm against losses from pure risks. Loss prevention, risk retention, and optimal insurance coverage are considered.

MSCI 6410. Mathematical Programming
3-0-3. Prerequisites: MSCI 6010 and consent of the College.
Survey of major results in linear programming, goal programming, and integer programming. Includes cases that illustrate issues of practical implementation.

MSCI 6411. Seminar in Mathematical Programming
3-0-3. Prerequisite: MSCI 6410.
Student research and/or in-depth study of recent literature on theory and application of mathematical programming in management and economics.

MSCI 6750. Stochastic Models in Management Science
3-0-3. Prerequisites: introductory probability (MATH 4215) and calculus (MATH 2308).
Stochastic process models for managerial contexts including production, congestion, cash flow, fisheries, and passenger reservations. Processes include birth and death, renewal and Markov. Also listed as MATH 6750.

MSCI 8401-2-3-4-5-6. Special Topics
1-0-1 through 6-0-6 respectively. Prerequisite: consent of the College.
Topics of current interest in the field of management science.

MSCI 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the College.
Provides project work experience in the field of management science.

MSCI 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate teaching assistantships.

MSCI 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the College.
For graduate students holding graduate research assistantships.

The College of Sciences and Liberal Studies (COSALS) comprises eight degree-granting Schools—Applied Biology, Chemistry, Geophysical Sciences (graduate degrees only), Information and Computer Science, Mathematics, Physics, Psychology, and Social Sciences (one graduate degree only)—and seven non-degree-granting departments—English, Modern Languages, Music, Physical Education and Recreation, Military Science (Army ROTC), Air Force Aerospace Studies (Air Force ROTC), and Naval Science (Navy ROTC).

All Tech undergraduates acquire skills and understanding prerequisite to their majors through COSALS courses in mathematics and the natural sciences. They satisfy breadth requirements in English, modern languages, psychology, and social sciences. Students will also find additional opportunities for career and life skills in music, ROTC, and intramurals.

A detailed description of each degree program in COSALS is located under the appropriate school heading, as are descriptions of the courses offered. COSALS courses required or recommended by the degree-granting programs in engineering, management, and architecture are listed under the curricula for those degrees.

Another opportunity, especially rich at the graduate level, is to take advanced courses in interdisciplinary areas and even to undertake thesis research under the joint direction of faculty members from different departments. Interdisciplinary programs include biochemistry, biophysics, molecular genetics, microbiology, biopsychology, applied statistics, and technology and science policy.

In addition to its degree programs, the College of Sciences and Liberal Studies offers students in good standing an opportunity to broaden their areas of expertise or acquire skills or information beyond their major degree requirements. With approval of their major school and in consultation with a designated adviser or committee in the school or department offering the certificate program, students may develop a coherent plan of study tailored to meet their individual needs and interests. Students who complete this special program satisfactorily will receive a certificate of recognition.

Certificate Programs
College of Sciences and Liberal Studies

School/ Department	Program
English	Technical and Business Communication American Literature Drama and Film
Geophysical Sciences	Geochemistry Geophysics Engineering Geology
Modern Languages	French German Spanish Linguistics
Physics	Applied Optics Computer-based Instrumentation
Psychology	Biopsychology Engineering Psychology Experimental Psychology

Industrial/
Organizational
Psychology
Social/Personality
Psychology

Social Sciences   History
Philosophy
Political Science
Sociology
International Affairs
Science, Technology,
and Society
Urban Studies

**T-4 (High School-
Level Teaching
Certificate)
Programs**   Biology
Chemistry
Mathematics
Physics

Certificate Programs are available at the bachelor's degree level.

Department of Air Force Aerospace Studies

Established in 1950

Professor and Head—Colonel Winston K. Pendleton; *Assistant Professors*—Captain John E. Fisher, Major John A. Hall, Major Peter P. Penny, Captain Robert D. Orozco, Major Michael D. Allen.

General Information

Air Force Reserve Officer Training Corps (AFROTC) program offers two phases. The first two years constitute the General Military Course (G.M.C.) and the last two years, the Professional Officer Course (P.O.C.).

Four-year Program

Students entering the four-year program enroll in AFROTC courses in the same manner in which they register for other undergraduate courses. A formal application is not required. Students enrolled in the G.M.C. incur no military obligation unless they are on an AFROTC scholarship. Those

students desiring to become commissioned officers in the Air Force must compete for entry into the P.O.C., which is normally taken during the last two years of college. Between the sophomore and junior years, cadets normally attend a four-week field training session conducted at an Air Force base. Students accepted for the P.O.C. become members of the Air Force Reserve and receive a tax-free subsistence allowance of $100 per month.

Two-year Program

The two-year program and the last two years of the four-year program are identical in academic content. The basic requirement for entry into this program is that the student must have two academic years remaining in school. This may be at the undergraduate or graduate level or a combination of the two. Selection of two-year applicants is predicated upon the same criteria as selection of four-year program cadets. In addition, candidates must successfully complete a six-week field training course at an Air Force base during the summer preceding their enrollment and be recommended to enter the P.O.C. upon their return to campus.

AFROTC College Scholarship Program

AFROTC college scholarships are available to qualified cadets in the two- and four-year programs. Scholarships cover tuition, matriculation, health services, student activities fees, and most books. All scholarship cadets also receive a tax-free subsistence allowance of $100 per month.

Courses of Instruction

AS 1610. Introduction to Today's Air Force
1-1-1.
    United States Air Force doctrine, mission, and organization, with an introduction to strategy.

AS 1620. Air Force Operational Activities
1-1-1.
    United States Air Force strategic and general purpose forces, emphasis on their mission, employment, and weapon systems.

AS 1630. Air Force Support Activities
1-1-1.
    A survey of support commands and operating agencies of the United States Air Force.

AS 2610. Air Power, the Early Years
1-1-1.
    A study of the principles of manned flight and doctrine of air power from the seventeenth century through the 1930s.

AS 2620. Air Power, World War II to Korea
1-1-1.
    An examination of the development of air power doctrines in World War II, the Berlin airlift, and the Korean War.

AS 2630. Air Power, the Later Years
1-1-1.
    An examination of the role of air power in contemporary times, including the Middle East, Cuba, and Southeast Asia.

AS 3410. Air Force Management I
3-1-3.
    Introduction to Air Force management, individual and group behavior, and communications skills.

AS 3420. Air Force Leadership
3-1-3.
    Analysis of leadership dynamics and principles as they apply to command and management.

AS 3430. Air Force Management II
3-1-3.
    Fundamentals, functions, and techniques of management. Stresses Air Force approach to management.

AS 4310. Civil-Military Relations
3-1-3.
    A study of the environment of current and historical civil military relations and the sociological aspects of the military profession.

AS 4320. United States Defense Policy
3-1-3.
    An organizational behavior investigation of the formulation and implementation of United States defense policy.

AS 4330. Military Justice
3-1-3.
    Functions of the military justice system. Stresses differences and similarities between civil and military law.

School of Applied Biology

Established in 1960

Director—Thomas G. Tornabene; *Professors* — Jerry S. Hubbard, Roger M. Wartell; *Associate Professors*—Gary L. Anderson, John R. Benemann, E. Lloyd Dunn, David B. Dusenbery, Paul Edmonds, Dwight H. Hall, John J. Heise, Gunther U. Holzer, Nancy W. Walls, Edward K. Yeargers; *Assistant Professors*—Jung Choi, W. Jack Jones, Samuel M. Politz; *Adjunct Appoint-*

ments—Ralph Messing, Fred K. Parrish, Charles F. Shaefer, Robert Shleser.

General Information

Programs of study offered by the School of Applied Biology allow students to gain competence in biotechnology, microbiology, genetics, environmental biology, and biophysics. The Institute, with its strength in science and technology, provides unique opportunities for training and research in the biological sciences. The curriculum encourages program enrichment by incorporating course selections from other schools and departments.

The Bachelor of Science degree program consists of a combination of requirements and electives that ensure the attainment of a broad background in biology with sufficient flexibility to satisfy a wide spectrum of individual interests and career objectives. The undergraduate curriculum in applied biology is well suited to prepare students for employment in industrial, academic, and government laboratories; for graduate study; or for medical, dental, veterinary, or other health profession schools. The minimum number of total hours required for a bachelor's degree in applied biology is 201.

The School of Applied Biology offers graduate programs that are flexible to serve the specific needs of the student. Also, the School encourages interdisciplinary programs involving other schools within the Institute.

Members of the faculty are actively engaged in research fields such as biophysics, cell and mammalian physiology, microbiology, microbial genetics, fermentation technology, cell immobilization, biochemical reactor design and modeling, natural product chemistry, and ecology.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
BIOL 1110-1-2 General Biology I, II, III	3-3-4	3-3-4	3-3-4
CHEM 1111-2, 2113 General Chemistry	4-3-5	4-3-5	3-3-4

ENGL 1001-2
Analysis of Literature and Language I, II; English elective

	1st Q.	2nd Q.	3rd Q.
English elective	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
TOTALS	15-6-17	X-X-17	X-X-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
BIOL 3331 Cell Physiology	.....	.....	3-3-4
BIOL 3332 Biostatistics	.....	4-3-5	.....
BIOL 3335 General Ecology	3-0-3	.....	.....
BIOL 3310 General Microbiology	3-6-5	.....	.....
Humanities Electives	3-0-3	3-0-3	3-0-3
Social Sciences Electives	3-0-3	3-0-3	3-0-3
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381-2 Organic Chemistry Laboratory	.....	0-6-2	0-6-2
Physical Education (requirements, p. 253)	.....	.....	X-X-3
TOTALS	14-6-17	13-9-16	X-X-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
BIOL 3334 Genetics	3-3-4	.....	.....
BIOL 4446 Animal Physiology 1	3-0-3	.....	.....
BIOL 4440 Plant Physiology	.....	.....	3-0-3
BIOL 4441 Physiology Laboratory	.....	.....	0-6-2
BIOL 4409 Microbial Physiology	.....	3-6-5	.....
PHYS 2121-2-3 Introductory Physics	4-3-5	4-3-5	4-3-5
Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Electives	.....	X-X-3	X-X-5
TOTALS	X-X-15	X-X-16	X-X-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
BIOL 4411 Industrial Microbiology	3-0-3	.....	.....
BIOL 4406 Medical Bacteriology	.....	.....	3-6-5
BIOL 4408 Microbial Genetics	3-6-5	.....	.....
BIOL 4437 Fermentation Laboratory	.....	1-9-4	.....
BIOL 4405 Virology	.....	3-0-3	.....
BIOL 4450 Seminar	.....	.....	2-0-2
Free Electives	X-X-9	X-X-10	X-X-10
TOTALS	X-X-17	X-X-17	X-X-17

ELECTIVES

See "Humanities and Social Sciences Requirements," Information for Undergraduate Students, pp. 41-42, for lists of approved courses. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

There are thirty-seven hours of electives beyond those required for humanities, social sciences, and physical education. Of these, fifteen hours must be earned in courses chosen from a list of courses approved by the School of Applied Biology; the remaining twenty-two hours are free electives.

Graduate Programs

The School of Applied Biology provides advanced training in a variety of areas. Current areas of specialization include the development of analytical techniques for biotechnology, biophysical analysis of DNA-protein interactions, genetic engineering, anaerobic fermentations, specialty chemical production by microorganisms, medical microbiology, developmental and sensory biology of nematodes, toxicology, and salt marsh plant physiology and ecology.

Master of Science Degree

The requirements for the M.S. degree are a master's thesis and thirty quarter hours of class work, which includes eighteen credit hours in a major field. Eighteen of the quarter hours must be in formal graduate-level courses. The thesis must be defended in an oral examination.

Doctor of Philosophy Degree

Each Ph.D. student must acquire a thorough knowledge of a selected area of specialization, a broad knowledge of the field, and competence in the basic sciences. In addition, the student is required to demonstrate a mastery of some other area of specialization (minor field). Admission to candidacy is obtained by passing written and oral examinations. The Ph.D. student must complete a comprehensive dissertation based on his or her research problem, some portion of which must be submitted for publication prior to the final defense of the dissertation.

Minimum credit-hour requirements are a total of seventy-seven, which include seventeen research credit hours and fifteen credit hours in an approved minor. A maximum of thirty-three credit hours from an M.S. program may be applied to the doctoral program.

Courses of Instruction

BIOL 1110. General Biology I
3-3-4. It is recommended but not required that General Biology be taken in the sequence 1110, 1111, and 1112.
An introduction to general biology at the cellular level with emphasis on cell structure, metabolic processes, and genetics.
Text: at the level of Curtis, *Biology*, 4th ed.

BIOL 1111. General Biology II
3-3-4. It is recommended but not required that General Biology be taken in the sequence 1110, 1111, and 1112.
An introduction to general biology at the whole organism level with an emphasis on physiological processes and integration of growth and development.
Text: at the level of Curtis, *Biology*, 4th ed.

BIOL 1112. General Biology III
3-3-4.
An introduction to general biology with an emphasis on evolution, ecology, animal behavior, and the diversity of living organisms.
Text: at the level of Curtis, *Biology*, 4th ed.

BIOL 1720. Biological Principles for Engineers
4-3-5.
The fundamentals of biology with an emphasis on interactions of human technology and biological systems.
Text: at the level of Davis and Solomon, *The World of Biology*, 3rd ed.

BIOL 3310. Introductory Microbiology I
3-6-5. Prerequisite: BIOL 1110, CHEM 3312, or consent of the School.
Basic biology of bacteria, fungi, algae, protozoa, and viruses, with particular emphasis on bacteriology.
Text: at the level of Brock, *Biology of Microorganisms*.

BIOL 3311. Introductory Microbiology II
3-6-5. Prerequisite: BIOL 3310 or consent of the School.
Classification and biology of bacteria and their role in soil, water, foods, and air.
Text: at the level of Brock, *Biology of Microorganisms*.

BIOL 3331. Cell Physiology
3-3-4. Prerequisite: BIOL 1110-1, CHEM 3311, or consent of the School.
Structure and functions of cells and their organelles, catabolism and energy metabolism, introductions to photosynthesis and biosynthesis, membrane structure and permeability properties.
Text: at the level of Wolf, *Biology of the Cell*, 2nd ed.

BIOL 3332. Biostatistics
4-3-5. Prerequisite: MATH 1308.
An introduction to statistical methods and their uses in the preparation and interpretation of biological experiments.
Text: at the level of Walpole and Myers, *Probability and Statistics for Engineers and Scientists*.

BIOL 3334. Genetics
3-3-4. Prerequisite: BIOL 1110 or consent of the School.
The principles of inheritance as described by Mendelian and biochemical genetics.
Text: at the level of Ayala and Kiger, *Modern Genetics*.

BIOL 3335. General Ecology
3-0-3. Prerequisite: either BIOL 1112 or 1720 or consent of the School.
Introduction to the concepts of ecology; designed for biology majors but appropriate for interested nonmajors. Emphasizes structure and function of natural populations, communities, and ecosystems.
Text: at the level of Colinvaux, *Ecology*.

BIOL 3337. General Ecology Laboratory
0-6-2. Prerequisite: BIOL 3335 or 1720 or consent of the School; may be taken concurrently with or following BIOL 3335.
An introduction to the analytical techniques and physical and chemical methods useful in modern ecological studies and practical applications of these techniques in field studies in major ecosystems of the southeastern United States.
Text: at the level of Cox, *Laboratory Manual of General Ecology*, 5th ed.

BIOL 3360. Human Genetics
3-0-3. Prerequisite: introductory biology or consent of the School.
The major concepts and problems of human genetics, designed to lead to a better understanding of how the genetic and environmental components interact to produce the human organism.
Text: at the level of Rothwell, *Human Genetics*.

BIOL 3711. Anatomy and Physiology
3-0-3. Prerequisite: junior standing or consent of the School.

Study of human anatomy and fundamental physiological mechanisms. Designed for the advanced student in fields interdisciplinary with the life sciences. Noncredit for biology majors.

Text: at the level of Grollman, *The Human Body*.

BIOL 3801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.

These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

BIOL 4405. General Virology
3-0-3. Prerequisite: BIOL 3310, 3331, or consent of the School.

An integrated view of virology, bringing unity to the diversity of bacterial, mammalian, insect, and plant viruses, with special emphasis on biochemical characterization of viruses and their reproduction.

Text: at the level of Luria, Darnell, Baltimore, and Campbell, *General Virology*, 3rd Ed.

BIOL 4406. Medical Bacteriology
3-6-5. Prerequisite: BIOL 3310 or consent of the School.

Advanced study of bacteria of medically important bacteria and their role in diseases and immunity.

Text: at the level of Burrows, *Textbook of Microbiology*.

BIOL 4408. Microbial Genetics
3-6-5. Prerequisite: BIOL 3310, 3331, 3334, or consent of the School.

Microbial genetics with special emphasis on the integration of genetic studies with biochemical and physical analysis of synthesis, structure, and function of nucleic acids and proteins.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd ed.

BIOL 4409. Microbial Physiology
3-6-5. Prerequisite: BIOL 3310, 3331, or consent of the School.

Discussions and laboratory investigations on the physiology of growth and metabolic activities of microorganisms.

Text: at the level of Stanier, Ingraham, Wheelis and Painter, *The Microbial World*, 5th ed.

BIOL 4410. Microbial Ecology
3-0-3. Prerequisite: BIOL 3310 or consent of the School.

Advanced discussions on microorganisms occupying key roles in recycling processes, microbial ecosystems, and microbial evolution.

Text: at the level of Atlas and Bartha, *Microbial Ecology: Fundamentals and Applications*.

BIOL 4411. Industrial Microbiology
3-0-3. Prerequisite: BIOL 3310 or consent of the School.

The biochemistry, genetics, and technological applications of microorganisms used in commercial processes.

Text: at the level of Crueger and Crueger, *Biotechnology, a Textbook of Industrial Microbiology*.

BIOL 4413. Air and Water Pollution
3-0-3.

An introduction to environmental, social, and economic problems resulting from air and water pollution and from current pollution abatement practices. Emphasis on concerns of engineers and biologists in environmental assessment.

Text: at the level of Hodges, *Environmental Pollution*, 2nd ed., and selected references.

BIOL 4415. Introductory Radiation Biology
3-3-4. Prerequisite: consent of the School.

A survey of the responses of biological systems to various kinds of radiations.

Text: at the level of Grosch and Hopwood, *Biological Effects of Radiations*.

BIOL 4416. Industrial Hygiene
3-0-3.

A survey of chemical, physical, and biological hazards in the occupational environment to include adverse effects on the body, methods of evaluation, general control measures, and governmental regulations.

Text: at the level of Olishifski and McElroy, *Fundamentals of Industrial Hygiene*, 2nd ed., and selected references.

BIOL 4420. Limnology
3-6-5. Prerequisite: BIOL 3335 or consent of the School.

Physics, chemistry, and ecology of aquatic communities and ecosystems. Physical, chemical, and biological investigations of lakes, streams, and estuaries. Laboratories include several field trips.

Text: at the level of Goldman and Horne, *Limnology*.

BIOL 4423. Population Biology
3-0-3. Prerequisite: BIOL 1112 or consent of the School.

Population ecology: dynamics and evolutionary mechanisms, including modes of selection and environmental modification of genetic systems.

Text: at the level of Wilson and Bossert, *A Primer of Population Biology*.

BIOL 4433. Recombinant DNA Laboratory
1-6-3. Prerequisite: BIOL 4408 or consent of the School.

Laboratory principles of recombinant DNA technology and genetic engineering, with emphasis on the preparation and cloning of DNA.

Text: at the level of Rodriguez and Tait, *Recombinant DNA Techniques: An Introduction*.

BIOL 4437. Fermentation Laboratory
1-9-4. Prerequisite: BIOL 4409, 4411, or consent of the School.

Laboratory principles of microbial technology with fermentations and the modifications of plant and animal products for food, beverages, feed, and products of industrial importance.

Text: at the level of Crueger and Crueger, *Biotechnology, a Textbook of Industrial Microbiology*.

BIOL 4440. Plant Physiology
3-0-3. Prerequisite: BIOL 3331, CHEM 3312.

Chemical transformations in photosynthesis, photophysiology and water relationships, organic nutrition and effects of hormones on growth and development in plants.

Text: at the level of Salisbury and Ross, *Plant Physiology*, 3rd ed.

BIOL 4441. Physiology Laboratory
0-6-2. Prerequisite: BIOL 3331 and 4440 or 4446.

The laboratory emphasizes training in the methods used to investigate important physiological principles in plants

and animals and the application of these methods in experimental design.

Text: at the level of Schottelius et al., *Physiology Laboratory Manual*.

BIOL 4446. General Animal Physiology I
3-0-3. Prerequisite: BIOL 3331, CHEM 3312, or consent of the School.

Vertebrate systems physiology, including muscles, nerves, circulation, respiration, and body fluid.

Text: at the level of Selkurt, *Physiology*.

BIOL 4448. General Animal Physiology II
3-0-3. Prerequisite: BIOL 3331, CHEM 3312, or consent of the School.

The physiology of the gastrointestinal, renal, endocrine, and reproductive systems. It is recommended that BIOL 4446 be taken prior to BIOL 4448.

Text: at the level of Selkurt, *Physiology*.

BIOL 4450. Seminar
2-0-2. Normally taken by seniors.

Student and staff presentations of reports on laboratory experiments or literature searches.

BIOL 4464. Developmental Genetics
3-0-3. Prerequisite: BIOL 3334 or consent of the School.

Transcriptional, translational, and posttranslational control of gene expression in cell differentiation, mechanisms of genomic regulation in eukaryotes, nucleocytoplasmic interactions, and genetic aspects of morphogenesis.

BIOL 4801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.

These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

BIOL 4960-1-2. Special Problems.
Credit hours to be arranged. Prerequisite: BIOL 1111.

Special laboratory problems in biology, to be given any quarter with credit (not to exceed seven hours) to be arranged.

BIOL 6170. Biophysical Genetics
3-0-3. Prerequisite: BIOL 3334 or equivalent.

Current understanding of the molecular mechanisms of genetic processes, DNA conformation in the cell, mechanisms of replication, transcription, and translation. Emphasis on bacterial systems.

BIOL 6608. Advanced Microbial Genetics
3-0-3. Prerequisite: BIOL 4408 or consent of the School.

Genetics of bacteria, plasmids, and viruses. Organization and regulation of expression of genetic material, with special emphasis on new techniques such as genetic engineering.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd ed.

BIOL 6609. Advanced Microbial Genetics Laboratory
0-6-2. Prerequisite: BIOL 4408 or consent of the School.

Production, isolation, and characterization of mutants. Testing for mutagens.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd ed.

BIOL 6611. Advanced Microbial Physiology
3-0-3. Prerequisite: BIOL 4409 and CHEM 4511-12 or consent of the School.

Advanced studies of selected aspects of the physiology of prokaryotic and eukaryotic microorganisms.

Text: Selected references.

BIOL 6612. Microbial Metabolism and Nutrition
3-0-3. Prerequisite: BIOL 6611.

A study of microbial systematics and microbial chemistry, with particular emphasis on catabolic events.

BIOL 6619. Ecological Systems
3-0-3. Prerequisite: graduate standing or consent of the School.

Fundamentals of ecology with emphasis on the structure and function of ecosystems. Application of ecosystem concepts to environmental impact analysis and environmental management. Designed primarily for planners and engineers; suitable for biologists.

BIOL 6622. Topics in Ecology
1-2-2. Prerequisite: BIOL 6619 or consent of the School.

Topics of current interest in environmental science, such as systems analysis, indicators of pollution, environmental impact evaluation, and environmental monitoring.

BIOL 6625. Communities and Ecosystems
3-0-3. Prerequisite: BIOL 3335, 3337 or consent of the School.

Theoretical and practical aspects of the description, analysis, classification, and current understanding of the functional processes in major communities and ecosystems of North America.

Text: literature, references, and review articles.

BIOL 6626. Physiological Ecology
3-3-4. Prerequisites: BIOL 3335 and either 4440, 4446, or 4448, or consent of the School.

Physiological adaptations of plants and animals to their environment. Measurements and analysis of environmental factors as well as organismal physiological responses to light, temperature, water, and mineral nutrients are emphasized.

Text: literature, references, and review articles.

BIOL 6646. Mammalian Physiology
3-3-4. Prerequisites: BIOL 4446, 4448, or equivalent or consent of the instructor.

Physical, biochemical, and biological phenomena underlying organ functions. Integration of physiological processes and basic techniques of physiological analysis.

BIOL 6649. Neurobiology
3-0-3. Prerequisites: CHEM 3313, PHYS 2122, BIOL 1111, or consent of the School.

An introduction to the basic mechanisms of neural function, with emphasis on cellular and molecular processes.

Text: at the level of Kuffler, Nicholls, and Martin, *From Neuron to Brain*, 2nd ed., plus selections from the literature.

BIOL 6664. Selected Topics in Regulatory Biology
3-0-3. Prerequisite: CHEM 4511-12-13 or consent of the School.

Metabolic regulation, "second messengers," cyclic AMP-prostaglandin interactions, positive and negative transcriptional control and catabolite repression.

BIOL 6676. Advances in Supramolecular Biology

3-0-3. Prerequisites: BIOL 1111, CHEM 3511 or PHYS 4251, and PHYS 2123 or consent of the School.

Advanced treatment of the organization and assembly of biological structures at a level of complexity between single molecules and cells (membranes, viruses, ribosomes).

Text: selected references.

BIOL 6730. Biological Effect of Radiations

3-3-4. Prerequisite: consent of the School.

An introduction to the effects of nuclear radiation upon biological systems for graduate students in the nuclear science and engineering curriculum.

Text: at the level of Grosch and Hopwood, *Biological Effects of Radiations*.

BIOL 7000. Master's Thesis

BIOL 8001. Seminar

2-0-2. Prerequisite: graduate standing.

Discussion group composed of staff and graduate students.

BIOL 8013-4-5. Seminar in Microbiology

2-0-2 each. Prerequisite: graduate standing.

Recent advances in microbial physiology and metabolism, industrial and applied microbiology, microbial ecology, medical microbiology, and immunology.

BIOL 8023-4-5. Seminar in Ecology

2-0-2 each. Prerequisite: graduate standing.

Topics of current interest and recent advances in the general areas of population growth and limitation, interspecific relationships, and the structure, productivity, and stability of ecosystems.

BIOL 8043-4-5. Seminar in Physiology

2-0-2 each. Prerequisite: graduate standing.

Current concepts of membrane structure, molecular and ionic transport mechanisms, endocrinology, cardiac, nervous, and muscular function, physiology of development. Student and faculty presentations.

BIOL 8063-4-5. Seminar in Genetics

2-0-2 each. Prerequisite: graduate standing.

Topics of current interest in the areas of cytogenetics, developmental genetics, molecular genetics, mutagenesis, and the genetics of man and populations. Student and faculty presentations.

BIOL 8101-2-3-4-5. Special Topics

1-0-1 to 5-0-5, respectively.

These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

BIOL 8504-5-6. Special Problems

Credit to be arranged.

BIOL 8997. Teaching Assistantship

Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

BIOL 8998. Research Assistantship

Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.

For graduate students holding graduate research assistantships.

BIOL 9000. Doctoral Thesis

School of Chemistry
Established in 1906

Director and Professor—Robert A. Pierotti; *Coordinator of Graduate Programs and Professor*—Raymond F. Borkman; *Coordinator of Undergraduate Programs and Associate Professor*—Harold R. Hunt; *Regents' Professors*—Eugene C. Ashby, William H. Eberhardt (emeritus), Hermengild A. Flaschka (emeritus), Leon H. Zalkow; *Julius Brown Chair*—Erling Grovenstein, Jr.; *Vasser Woolley Chair*—Herbert O. House; *Professors*—E. Kent Barefield, J. Aaron Bertrand, Richard F. Browner, Edward M. Burgess, Ronald H. Felton, Richard W. Fink, Sidney L. Gordon, Charles L. Liotta, Sheldon W. May, George A. Miller, Thomas F. Moran, Henry M. Neumann, James C. Powers, Donald J. Royer, James A. Stanfield (emeritus), Peter E. Sturrock, Fred L. Suddath, Laren M. Tolbert, Nai-Teng Yu; *Associate Professor*—Lawrence A. Bottomley; *Assistant Professors*—Richard A. Ikeda, Patrick G. McDougal.

General Information

Included in the School are courses in chemistry required for various engineering and science curricula; for students interested in medical school; for the degree Bachelor of Science in Chemistry; and for graduate work leading to the degrees Master of Science in Chemistry and Doctor of Philosophy in Chemistry.

Undergraduate Program

Students receive the degree Bachelor of Science in Chemistry upon the completion of the following prescribed curriculum of which eighty-eight quarter hours are elective work. The significant number of free elective hours in the chemistry curriculum permits the students to take necessary concentrated elective work to achieve certificate programs in written and oral communications, foreign languages, social sciences, and other available programs of the Institute. In addition, interdisciplinary minor options in geochemistry and T-4 certification (in association with Georgia State University) are also possible. The judicious use of these free electives also enables the student to achieve considerable knowledge of other disciplines at Georgia Tech, such as chemical engineering, physics, mathematics, management, textiles, ceramics, and biology. These electives enable those who are interested in medical and dental schools to meet admission requirements of these schools.

Additional information regarding undergraduate programs is available by writing to the Undergraduate Coordinator, School of Chemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400.

Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1111-2 General Chemistry	4-3-5	4-3-5	.....
CHEM 2114 Chemical Principles	.....	.....	3-0-3
CHEM 2115 Quantitative Measurements	.....	.....	1-6-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
Modern Languages Electives	3-0-3	3-0-3	3-0-3
Physical Education (requirements, p. 253)	....	....	3-0-3
Free Electives	2-0-2	2-0-2	2-0-2
TOTALS	17-3-18	17-3-18	17-6-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381-2 Organic Chemistry Laboratory	.....	0-6-2	0-6-2
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
English Elective	.....	.....	3-0-3
Free Electives	3-0-3	3-0-3	3-0-3
TOTALS	15-3-16	15-9-18	13-9-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 3383 Organic Chemistry Laboratory	0-6-2	.....	.....
CHEM 3411-2-3 Physical Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3481-2 Physical Chemistry Laboratory	.....	0-6-2	0-6-2
CHEM 3121-2 Inorganic Chemistry	.....	3-0-3	3-0-3
CHEM 4211-2 Instrumental Analysis 1, II	3-6-5	3-6-5	.....
English Elective	3-0-3	.....	.....
Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Electives	.....	.....	X-X-5
TOTALS	12-12-16	12-12-16	X-X-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Chemistry Electives	X-X-5	X-X-5	X-X-5
Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Electives	X-X-8	X-X-6	X-X-6
TOTALS	X-X-16	X-X-14	X-X-14

SUBSTITUTIONS

CHEM 2114 is prerequisite for CHEM 3311. If CHEM 2113 is taken, it may be used as a prerequisite for CHEM 3311. Students transferring into chemistry from other majors who have completed CHEM 2113 may substitute CHEM 2113 plus two hours of technical electives for CHEM 2114 and CHEM 2115. CHEM 3386 may be substituted for CHEM 3383 and one of the two required senior elective lecture-laboratory courses.

ELECTIVES

Modern Languages Electives

The School of Chemistry requires that a modern language (French, German, or Russian) be taken and recommends that it be taken in the freshman year. However, if social

sciences are elected in the freshman year, nine credit hours of a modern language must be taken later.

English Electives
The School of Chemistry recommends that two courses be taken from among these written and oral communication courses: ENGL 3010, 3015, 3020, 4015, 4020; however, the student may prefer to elect two literature courses in English.

Social Sciences Electives
See "Information for Undergraduates" for information relative to the Institute requirement of eighteen hours of humanities and eighteen hours of social sciences (pp. 41-42). All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives
These free electives may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled (see p. 34).

The required hours of free electives (forty) allow the student to take additional courses in chemistry beyond those required for the B.S. degree or courses in other disciplines. Students may wish to use their free electives to take a substantial number of courses in a particular discipline or closely related group of disciplines outside of chemistry. The School of Chemistry has identified several groups of courses that constitute coherent programs in areas related to chemistry. A student who elects to take twenty hours or more of credit from such an approved group of courses outside of chemistry may apply for approval to substitute up to six hours of the credit earned for a portion of the chemistry elective credit required for the B.S. degree. Information about these programs can be obtained from the undergraduate coordinator or from undergraduate academic advisers. In order to minimize scheduling problems, students are advised to plan their free elective programs during the early part of the sophomore year.

Chemistry Electives
The required hours of chemistry electives allow students to specialize in a particular area of chemistry by taking advanced undergraduate and/or graduate courses for which they are qualified. The fifteen credit hours in elective chemistry must include at least two lecture-laboratory courses selected from the following list: CHEM 3386, 3492, 4182, 4231, 4582. The remaining nine credit hours of chemistry electives may consist of up to four credit hours in special problems (CHEM 4901-3), CHEM 3511, courses numbered 4XXX, 6XXX, or other courses approved by the School; however, CHEM 4201 or 4701 may not be used as chemistry electives. Alternatively, a portion of these nine credit hours of chemistry electives may be replaced by credits earned in a discipline outside of chemistry, as described above under "Free Electives."

Graduate Programs
The School of Chemistry offers programs for the master's and doctoral degrees in the fields of analytical, biochemistry, inorganic, nuclear, organic, and physical chemistry.

The requirements for the master's degree consist of an accepted program of thirty quarter hours of course work plus an original research thesis on the master's level. The student and his or her advisory committee design the program, which may be largely or totally in chemistry, to suit the needs and objectives of the individual.

The goal of the doctoral program is greater proficiency and depth in the chemical area, with particular emphasis being placed on original, independent, and scholarly research. The only course work demanded is the Institute requirement of a minimum of fifteen earned credit hours in a minor field, which may be any field of study chosen by the student in consultation with his or her adviser. The area need not necessarily be beyond the broad area of chemistry. Most students, however, do take a number of courses during their studies beyond the minor requirements. The numbers of such other courses vary with individuals, the major field interests, and previous background, as well as long-range goals.

Active research fields include (1) biochemistry—proteolytic enzymes and inhibitors, neurochemistry, protein X-ray crystallography and molecular modeling, Raman and fluorescence spectroscopy of proteins, spectroscopy and photochemistry of ocular lenses and proteins, and antitumor agents of natural and synthetic origin; (2) inorganic chemistry—synthesis and properties of organometallic and coordination compounds, kinetics and mechanisms of reactions, metal hydrides, models for biologically active metal-containing compounds, X-ray diffraction, ESR spectroscopy, and magnetic susceptibility; (3) organic chemistry—multistep synthesis, physical organic chemistry, heterocyclic chemistry, natural products, organometallic chemistry, crown ethers, electrochemistry, theoretical organic chemistry, carbanions, and phase transfer catalysis; (4) physical chemistry—molecular and ion beam kinetics, *ab initio* calculations, electronic spectroscopy, light scattering, Raman spectroscopy, surface phenomena, protein dynamics and photochemistry, bonding theory, EXAFS, NMR spectroscopy, and porphyrin properties; (5) Analytical chemistry—electrochemistry, mass spectrometry, atomic absorption, RF plasmas, and porphyrin chemistry; and (6) nuclear chemistry—X-ray fluorescence, radiopharmaceuticals, inner shell ionization, and radioactive isotopes.

Additional information regarding graduate work is available by writing to the Graduate Coordinator, School of Chemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400.

Courses of Instruction
Note: All students are required to wear safety glasses while working in the laboratories. The glasses will be provided at the student's expense.

CHEM 1100. General Chemistry I
4-4-5. Prerequisite: consent of the School.
This course, covering the fundamental laws and theories of chemistry, is identical to CHEM 1101 and comparable to CHEM 1111. It may be taken, upon approval, by students who may need additional lecture, drill, or laboratory periods in order to complete the regular first-quarter work in college chemistry. Credit is not allowed for both CHEM 1100 and either CHEM 1101 and/or

CHEM 1111. The course serves as a prerequisite to CHEM 1102 or 1112.
Text: at the level of Mortimer, *Chemistry*, 6th ed.

CHEM 1101-2. General Chemistry I, II
4-3-5 each.
Fundamental laws and theories of chemistry for students who do not plan to take advanced chemistry courses.
Text: at the level of Mortimer, *Chemistry*, 6th ed.

CHEM 1111-2. General Chemistry I, II
4-3-5 each.
For students planning to pursue advanced courses in chemistry. In-depth studies of chemical principles and the techniques of quantitative analysis necessary for further studies in chemistry.
Text: at the level of Segal, *Chemistry, experiment and theory*.

CHEM 2113. Chemical Principles
3-3-4. Prerequisite: CHEM 1112 or 1102.
Continuation of CHEM 1112, stressing thermodynamics and kinetics and their applications to chemistry. Quantitative experimentation.
Text: at the level of Segal, *Chemistry, experiment and theory*.

CHEM 2114. Chemical Principles
3-0-3. Prerequisite: CHEM 1112 or 1102.
Continuation of CHEM 1112, stressing thermodynamics and kinetics and their application to chemistry. For chemistry majors.

CHEM 2115. Quantitative Measurements
1-6-3. Prerequisite: concurrent with or following CHEM 2114; or CHEM 2113.
Experimentation concerned with synthesis, analysis, and data interpretation. For chemistry majors.

CHEM 2901-2-3. Special Problems—Chemistry
Credit hours to be arranged. Prerequisites: CHEM 1112 and consent of the School.
Individualized instruction, which will include library, conference, and laboratory experiences.

CHEM 3121-2. Advanced Inorganic Chemistry I, II
3-0-3. Prerequisite: CHEM 3411.
A study of the reactions and structures of inorganic compounds and the principles, generalizations, and theories that assist in understanding their behavior.
Text: at the level of Douglas, McDaniel and Alexander, *Concepts and Models of Inorganic Chemistry*, 2nd ed.

CHEM 3311-2-3. Organic Chemistry I, II, III
3-0-3 each. Prerequisite: CHEM 2113, 2114, or consent of the School.
Principal classes of organic compounds, aliphatic and aromatic.
Text: at the level of Morrison and Boyd, *Organic Chemistry*, 4th ed.

CHEM 3381-2. Organic Chemistry Laboratory I, II
0-6-2 each. Prerequisites: CHEM 3311-2; CHEM 3381 prerequisite to 3382.
Studies of reactions, preparations and the techniques used in the organic laboratory.

CHEM 3383. Organic Chemistry Laboratory
0-6-2. Prerequisite: CHEM 3382. Pre- or corequisite: CHEM 3313.
Studies of reactions, preparations, and the techniques used in the organic laboratory.

CHEM 3386. Organic Chemistry Laboratory
1-12-5. Prerequisite: CHEM 3382. Pre- or corequisite: CHEM 3313.
Advanced study of organic reactions, preparations, separations, instrumentation, and techniques.

CHEM 3411. Physical Chemistry I
3-0-3. Prerequisite: CHEM 2113 or 2114, PHYS 2122, MATH 2307.
Quantum mechanics and atomic structure, bonding theory, molecular spectroscopy.
Text: at the level of Adamson, *Physical Chemistry*, 3rd ed.

CHEM 3412. Physical Chemistry II
3-0-3. Prerequisite: CHEM 2113 or 2114, PHYS 2122, MATH 2307.
Chemical thermodynamics, energetics of chemical reactions, and changes of state.
Text: at the level of Adamson, *Physical Chemistry*, 3rd ed.

CHEM 3413. Physical Chemistry III
3-0-3. Prerequisite: CHEM 3412.
Electrochemistry, rates of chemical reactions, kinetic theory of gases, statistical mechanics.
Text: at the level of Adamson, *Physical Chemistry*, 3rd ed.

CHEM 3481. Physical Chemistry Laboratory I
0-6-2. Pre- or corequisite CHEM 3412.
Applications of physical chemistry principles.

CHEM 3482. Physical Chemistry Laboratory II
0-6-2. Prerequisite: CHEM 3481; Pre- or corequisite CHEM 3413.
Applications of physical chemistry principles.

CHEM 3492. Physical Chemistry Laboratory III
1-6-3. Prerequisite: CHEM 3482; Pre- or corequisite: CHEM 4401 or consent of the School.
Application of electronic spectroscopy to vibrational, rotational, and electronic properties of simple molecules. Kinetic properties of reacting systems emphasizing molecular, dynamic properties.

CHEM 3511. Biochemistry
3-0-3. Prerequisite: CHEM 3312.
Introductory course in biochemistry dealing with the chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids, and other biomolecules.
Text: at the level of Lehninger, *A Short Course in Biochemistry*.

CHEM 4182. Synthetic Inorganic Chemistry
1-6-3. Pre- or corequisite: CHEM 3121.
Preparation and characterization of inorganic compounds, with special emphasis on the apparatus and techniques employed in modern synthetic inorganic chemistry.

CHEM 4201. Analytical Chemistry for Nonchemists
2-3-3. Prerequisite: CHEM 2113.

Provides a background to modern analytical chemistry and to instrumental methods of analysis with applications to engineering and other areas. Not open to chemistry majors.
Text: at the level of Braun, *Introduction to Chemical Analysis*.

CHEM 4211. Instrumental Analysis I
3-6-5. Prerequisite: CHEM 2113 or 2115; Pre- or corequisite CHEM 3411.
Introduction to both theory and practice of modern instrumental methods: polarography, spectroscopy, colorimetry, microscopy, polarimetry, electroanalytical methods.
Text: at the level of Skoog and West, *Fundamentals of Analytical Chemistry*, 4th ed.

CHEM 4212. Instrumental Analysis II
3-6-5. Prerequisite: CHEM 4211; Pre- or corequisite: CHEM 3412.
Continuation of Instrumental Analysis I.
Text: at the level of Skoog, *Principles of Instrumental Analysis*, 3rd ed.

CHEM 4231. Advanced Instrumental Analysis
1-6-3. Prerequisite: CHEM 4211 or consent of the School.
Advanced analytical techniques and investigations of newer analytical methods in the practice of analysis.

CHEM 4311. Organic Reactions I
3-0-3. Prerequisite: CHEM 3313.
Theoretical interpretation of reactivity, reaction mechanisms, and molecular structures of organic compounds.

CHEM 4341. Applied Spectroscopy
3-0-3. Prerequisite: CHEM 3313.
Interpretation of spectroscopic and other common methods of organic analysis and structure determinations.

CHEM 4401. Physical Chemistry
3-0-3. Prerequisites: CHEM 3411, PHYS 2123, and MATH 2308 or consent of the School.
Theory of molecular spectroscopy, electron diffraction, X-ray diffraction, neutron diffraction, and magnetic methods applied to the determination of molecular structure.

CHEM 4452. Chemistry of the Solid State
3-0-3. Prerequisite: CHEM 4311 or consent of the School.
Applications of the concepts of physical chemistry to the structure of solids and their chemical and physical properties.

CHEM 4511-2-3. Biochemistry I, II, III
3-0-3. Prerequisite: CHEM 3312 or consent of the School.
The chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids, and other biomolecules.
Text: at the level of Lehninger, *Biochemistry*.

CHEM 4582. Biochemistry Laboratory
1-6-3. Prerequisite: CHEM 3511 or consent of the School.
Laboratory techniques in the isolation and characterization of proteins and nucleic acids, with special emphasis on modern practices in biochemistry.

CHEM 4701. Chemistry of Nuclear Technology
3-3-4. For students in nuclear engineering.
Principles of inorganic, radiation, and radio chemistries, separation methods for actinide elements and fission products and topics related to production and utilization of nuclear energy.

CHEM 4801-2-3. Special Topics—Chemistry
1-0-1 through 3-0-3 respectively. Prerequisite: junior standing or consent of the School.
Lecture courses in special topics of current interest in chemistry. Topics will vary from year to year.

CHEM 4901-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of the School.
Individualized instruction, which will include library, conference, and laboratory work.

CHEM 6111-2. Advanced Inorganic Chemistry I, II
3-0-3 each. Prerequisite: consent of the School.
The theory of bonding and structure of inorganic compounds and the chemistry of the elements.
Text: at the level of Huheey, *Inorganic Chemistry*, 3rd ed.

CHEM 6141. Chemical Applications of Group Theory
3-0-3. Prerequisite: CHEM 3112 or consent of the School.
An introduction to basic definitions and theorems of group theory and their application to molecular symmetry and quantum mechanics and use in valence bond, molecular orbital, and ligand field treatments.
Text: at the level of Flury, *Symmetry Groups*.

CHEM 6151. Chemical Crystallography
3-0-3. Prerequisite: consent of the School.
Applications of X-ray diffraction to the determination of crystal structures, including crystal symmetry, reciprocal lattice, intensity of diffraction, the phase problem, and refinement of structure parameters.

CHEM 6211-2. Analytical Chemistry I, II
3-0-3 each. Prerequisite: consent of the School.
Theoretical principles and uses of modern instrumental methods: spectroscopy, microscopy, colorimetry, polarography, polarimetry, and electroanalytical methods.
Text: at the level of Skoog and West, *Fundamentals of Analytical Chemistry*, 4th ed., and Skoog, *Principles of Instrumental Analysis*, 3rd ed.

CHEM 6231. Electroanalytical Chemistry
3-0-3. Prerequisite: CHEM 4212 or consent of the School.
Coulometry, electrolytic separations, polarography, chronopotentiometry, coulometric titrations and voltametric methods of equivalence point detection.
Text: at the level of Bard, *Electrochemical Methods*.

CHEM 6241. Advanced Analytical Chemistry
3-0-3. Prerequisite: consent of the School.
Competing equilibria, including polybasic acids, differential precipitation, complex ion formation in competition with these. Complexometric titrations and homogeneous precipitation. Adsorption, partition, ion exchange, and gas chromatography.

CHEM 6311-2-3. Organic Chemistry I, II, III
3-0-3 each. Prerequisite: CHEM 3313 and consent of the School.
A more advanced study of the fundamental reactions and theories of structure of various classes of organic compounds.
Text: at the level of House, *Modern Synthetic Reactions*, 2nd ed.

CHEM 6321-2-3. Reactivity, Mechanism, and Structure in Organic Chemistry I, II, III
3-0-3 each. Prerequisite: consent of the School.

Theoretical interpretations of reactivity, reaction mechanisms, and molecular structures of organic compounds.

CHEM 6342. Instrumental Methods of Organic Analysis
3-0-3. Prerequisite: CHEM 3313 or consent of the School.
Interpretation of spectroscopic and other common methods of organic analysis and structure determinations.

CHEM 6411-2. Molecular Structure and Chemical Principles I, II
3-0-3 each. Prerequisite: consent of the School.
A discussion of molecular structure based upon quantum mechanical principles.

CHEM 6421-2. Chemical Thermodynamics I, II
3-0-3 each. Prerequisites: CHEM 3411-2-3.
Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

CHEM 6451. Surface Equilibria
3-0-3. Prerequisite: consent of the School.
Classical and statistical thermodynamics of surface systems, intermolecular forces at the gas-solid interface, adsorption phenomena, and capillarity.

CHEM 6511-2. Advanced Enzymology I, II
3-0-3 each. Prerequisite: CHEM 4513 or consent of the School.
Structure and chemistry of proteins, enzyme structure and mechanism, enzyme kinetics, enzyme inhibitors, and medicinal chemistry.

CHEM 6541. Advanced Biophysical Chemistry
3-0-3. Prerequisites: CHEM 3411 and 3412, or consent of the instructor.
Applications of the principles and techniques of physical chemistry in biochemistry, with emphasis on the equilibrium and dynamic behavior of macromolecules in solution.

CHEM 6610. Nuclear Chemistry
4-0-4. Prerequisites: CHEM 3413 and MATH 2308.
Properties and structure of the atomic nucleus, radioactivity and decay schemes, interaction of radiation with matter, detection and experimental methods, nuclear reactors, radiochemical techniques.
Text: at the level of Friedlander. *Nuclear and Radiochemistry*.

CHEM 6612. Nuclear Chemistry
3-0-3. Prerequisite: CHEM 6610.
A continuation of CHEM 6610.

CHEM 6621. Fast-neutron Interactions
3-0-3. Prerequisite: CHEM 6612 or consent of the School.
Properties of the neutron. Forces between nucleons. Fast-neutron sources. Experimental methods of detection, spectrometry, and calibration of neutrons and neutron sources.

CHEM 6622. Nuclear Fission
3-0-3. Prerequisite: CHEM 6612 or consent of the School.
Theory, probability, mass and charge distributions, fragmentations, low-, intermediate-, and high-energy processes, and photofission processes occurring in nuclear fissions.

CHEM 6623. Elemental Analysis by Nuclear and X-ray Techniques
3-0-3. Prerequisite: consent of the School.
Elemental analysis by activation techniques, prompt neutron-capture gamma ray analysis, inelastic scattering analysis, instrumental and radiochemical methods, X-ray emission and fluorescence, and miscellaneous nuclear-based techniques.

CHEM 6754. Electrochemistry
3-0-3. Prerequisite: consent of the School.
A study of electrochemical instrumentation; thermodynamics, structure, double layer theory, and kinetics of simple and complex electrode processes. Also taught as CHE 6754.

CHEM 7000. Master's Thesis

CHEM 7121. Ligand Field Theory
3-0-3. Prerequisite: CHEM 6141.
Introduction to theory of electronic structure of transition metal compounds and its application to the interpretation of physical and chemical properties of these compounds—especially spectral and magnetic properties.

CHEM 7141. Mechanisms of Inorganic Reactions
3-0-3. Prerequisite: CHEM 3112 or consent of the School.
Discussion of mechanisms of inorganic reactions based on kinetic and stereochemical studies—the substitutions and redox reactions of coordination complexes in solution.

CHEM 7421. Statistical Thermodynamics
3-0-3. Prerequisite: CHEM 6422 or consent of the School.
A study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions, and cluster theory.

CHEM 7431-2. Principles of Quantum Mechanics I, II
3-0-3. Prerequisite: CHEM 6411 or PHYS 4143.
Important concepts of quantum chemistry at the intermediate level, including angular momentum, perturbation theory, electronic structure of molecules, and radiation matter interaction. Applications will vary from year to year.

CHEM 7451. Chemical Kinetics
3-0-3. Prerequisites: CHEM 6421-2.
Mechanisms of chemical reactions, cross sections, and rate constants. Elastic, inelastic, and rearrangement channels are discussed, using quantum and semiclassical techniques.

CHEM 8000. Seminar—Chemistry

CHEM 8111-2. Special Topics in Inorganic Chemistry
3-0-3 each. Prerequisite: CHEM 3112.
Topics to be discussed vary from year to year but will include mechanisms of inorganic reactions, Ligand field theory, and bonding in inorganic compounds.

CHEM 8211. Special Topics in Analytical Chemistry
2-3-3. Prerequisite: consent of the School.
Discussions of specialized areas of analysis, including spectrophotometry, polarography, coulometry, chro-

matography, and others. Content of course varies from year to year.

CHEM 8311-2. Special Topics in Organic Chemistry
3-0-3 each. Prerequisite: consent of the School.
Topics vary from year to year but will include subjects as evaluation of synthetic methods and their application to research in organic chemistry.

CHEM 8351-2. Special Topics in Biochemistry
3-0-3 each. Prerequisite: CHEM 4513 or consent of the School.
Topics vary from year to year but will include proteins, enzyme mechanisms, metabolism, membranes, and nucleic acids.

CHEM 8411-2. Special Topics in Physical Chemistry
3-0-3 each. Prerequisite: CHEM 3413 or consent of the School.
Topics vary from year to year will include subjects such as photochemistry, solid state, surface chemistry, and radiation chemistry.

CHEM 8461. Special Topics in Nuclear Chemistry
3-0-3. Prerequisite: CHEM 6612 or consent of the School.
Topics vary from year to year but will include nuclear fission, radiochemical techniques, nuclear reactions, inbeam nuclear spectroscopy, and online investigations of nuclei far from stability.

CHEM 8500-1-2. Special Problems—Chemistry
Credit to be arranged. Prerequisite: consent of the School.
A laboratory course dealing with special problems of current interest in chemistry.

CHEM 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

CHEM 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

CHEM 9000. Doctoral Thesis

Department of English

Acting Department Head—Elizabeth Evans; *Professors*—Annibel Jenkins, L. Hugh Moore, Helen H. Naugle, Larry J. Rubin, Maxine T. Turner, A. D. VanNostrand, James D. Young; *Associate Professors*— Edith H. Blicksilver, James J. Bynum, Wister J. Cook, Irving F. Foote, Frantisek W. Galan, Sarah E. Jackson, Peter J. McGuire, Matthew C. O'Brien, Sara Putzell, Esta K. Seaton, Jay P. Telotte, Robert E. Wood; *Assistant Professors*—May C. Brown, Richard J. Corbin, Sandra Corse, Richard A. Grusin, Kenneth Knoespel, Robert M. Markley, Paul Privateer, Carol Senf.

General Information
The Department of English offers instruction in basic composition (ENGL 1001-2), which is prerequisite for all other English courses. It provides programs in which students can complete the Institute humanities requirement as well as a nonhumanities credit program in technical writing and public speaking.

Humanities Programs and Certificates
The Department offers four humanities programs: American Literature, Drama and Film, Literature and Science, and the Western Tradition in Literature and Art. All courses in these programs carry humanities credit. Certificates are available in American Literature, Drama and Film, and Technical and Business Communication.

American Literature contains two tracks, "American Approaches to Poetry, Fiction, and Drama" and "The Southern Literary Tradition." Both groups of courses investigate how American cultural events, historical movements, and philosophies influenced and were influenced by the national literature. Students may also create an individual track with the help of an adviser from the program.

Drama and Film offers courses on specific periods, authors, social issues, and techniques in the history of these two related media.

The Literature and Science courses challenge the conventional opposition of the so-called "two cultures." Two questions guide each course: What is the structure of understanding in literary and scientific inquiry? Historically considered, what relations have existed between prevailing scientific theories, literary forms, and intellectual perspectives that constitute a society's way of knowing the world?

The Western Tradition in Literature and Art offers courses in Western world literature. These courses include historical surveys, as well as studies of specific literary and cultural traditions.

Technical and Business Communication Certificate Program
These courses teach the principles of effective communication and give practice in applying them in the practical form of briefings, speeches, memoranda, technical reports, and other standard forms of business communication. (None of the courses in this program carries humanities credit.)

Advanced Placement
Students with a score of 4 or 5 on the College Entrance Examination Board Advanced Placement Examination in Composition and Literature or Language and Composition receive credit for ENGL 1001-2. Students with College Board SAT Verbal scores of 650 (or 600 with English Achievement scores of 600) may take the Department advanced placement exam during FASET. Those who pass the Department exam and then earn an A or B in a Department literature course will receive credit for ENGL 1001-2 as well as for the course taken.

Regents' Examination
This exam measures proficiency in reading and English composition. A passing score is required by the Board of Regents for graduation. Students who have not passed the exam by the time they have completed fifty hours of degree credit must schedule ENGL 0020 in their following quarter in residence. In addition to ENGL 0020, the Department offers short workshops in preparation for the exam, consultation with those who have failed, and an appeal system for those who fail.

Courses of Instruction
ENGL 0020. Writing the Impromptu Essay
3-0-3. Pass/fail basis only.
Special attention given to developing basic skills in writing for students who need additional preparation for college-level English. Lectures, exercises. Cannot be counted for credit toward graduation.

ENGL 1001-2. Analysis of Literature and Language I, II
3-0-3 each. Freshman year. Courses must be taken in numerical sequence and are prerequisite to all other English courses.

A study of literary and expository texts to determine rhetorical strategies. Intensive writing practice in these strategies, with emphasis on organizing ideas, evidence, and readership in paragraph sequences and then on forecasting and monitoring paragraph sequences.

ENGL 2004. Survey of English Literature
3-0-3. Prerequisites: ENGL 1001-2.
A study of English literature since Shakespeare, with emphasis on significant figures and their works. Lectures, reports, papers, quizzes.

ENGL 2037-8-9. Acting and Producing the Play I, II, III
0-3-1 each.
Participation in the DramaTech production of plays through a variety of activities, including not only acting but also crew work: set design and building, publicity, accounting and sales, box office, lights, sound, make-up and costumes, special effects, stage managing.

ENGL 2041-2-3. Literature for International Students
3-0-3 each. Prerequisites: FL 1031-2-3. Sophomore year.
An introduction to American literature, with continued training in writing and speaking American English.

ENGL 2101. Introduction to Drama and Film
3-0-3. Prerequisites: ENGL 1001-2.
Investigates shared characteristics and differences between film and drama.

ENGL 2201. Introduction to American Literature
3-0-3. Prerequisites: ENGL 1001-2.
Major themes of optimism, guilt and doubt, and nature in the development of American literature.

ENGL 2301. Introduction to Literature and Science
3-0-3. Prerequisites: ENGL 1001-2.
The role of assumptions and expectations in many different kinds of understanding: poetry, painting, science, prose fiction, and literary criticism.

ENGL 2401. Introduction to the Western Tradition in Literature and Art
3-0-3. Prerequisites: ENGL 1001-2.
Explores major ideas of the Western humanities as revealed in ancient and modern literary masterpieces.

ENGL 3006. The English Language
3-0-3. Prerequisites: ENGL 1001-2.
Study of the origin of the English language, its relation to other languages, and its differentiation and development into modern English and American.

ENGL 3010. Issues in Professional Communication
3-0-3. Prerequisites: ENGL 1001-2. Does not carry humanities credit.
Introduces major issues in technical communication, including readability theory, audience analysis, documentation techniques, and the principles of document design through examples of professional writing. Taught as lecture/workshop.

ENGL 3015. Public Speaking
3-0-3. Prerequisites: ENGL 1001-2. Normally taken by juniors and seniors. Does not carry humanities credit.
Instruction in the basic principles of effective public speaking, with emphasis on practice and criticism. The course is conducted as a laboratory.

ENGL 3020. Technical Writing
3-0-3. Prerequisites: ENGL 1001-2. Does not carry humanities credit. Junior or senior year.
Focuses on the technical report. Includes preliminary instruction in letter and memoranda writing.

ENGL 3037-8-9. Acting and Producing the Play I, II, III
0-3-1 each. Prerequisites: ENGL 2037-8-9.
See ENGL 2037-8-9.

ENGL 3041. Writers in the Age of Galileo
3-0-3. Prerequisites: ENGL 1001-2.
Study of works of three of the following: Donne, Bacon, Jonson, Milton, Defoe. Emphasis on their reflection of social, scientific, and philosophical attitudes of the age.

ENGL 3042. Writers in the Age of Newton
3-0-3. Prerequisites: ENGL 1001-2.
Study of the works of three of the following: Swift, Fielding, Thoreau, Wordsworth, Keats. Emphasis on their reflection of social, scientific, and philosophical attitudes of the age.

ENGL 3043. Writers in the Age of Darwin
3-0-3. Prerequisites: ENGL 1001-2.
Study of works of three of the following: Carlyle, Melville, Arnold, Tennyson, Twain. Emphasis on their reflection of social, scientific, and philosophical attitudes of the age.

ENGL 3044. Writers in the Age of Freud and Einstein
3-0-3. Prerequisites: ENGL 1001-2.
Study of works of three of the following: James, Yeats, Shaw, Lawrence, Eliot. Emphasis on their reflection of social, scientific, and philosophical attitudes of the age.

ENGL 3051. Chaucer I
3-0-3. Prerequisites: ENGL 1001-2.
Introduction to the poetry of Chaucer in Middle English. Major emphasis on the study of *The Canterbury Tales*.

ENGL 3056. Joyce
3-0-3. Prerequisites: ENGL 1001-2.
A study of the works of James Joyce, with particular emphasis on Joycean techniques of fiction as developed in *Ulysses* and other selected works.

ENGL 3058. Contemporary Drama
3-0-3. Prerequisites: ENGL 1001-2.
An analytic survey of prominent playwrights and trends in contemporary drama. Lectures, reports, collateral reading, quizzes.

ENGL 3059. Contemporary Fiction
3-0-3. Prerequisites: ENGL 1001-2.
An analytic study of prominent writers and trends in contemporary fiction. Lectures, reports, collateral reading, quizzes.

ENGL 3072. The Civil War in Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
A study of selected works of literature dealing with the American Civil War, with emphasis on the relation of history and literature.

ENGL 3076. Faulkner
3-0-3. Prerequisites: ENGL 1001-2, 2201.

A study of selected works of William Faulkner, with particular emphasis on major themes and the nature of his narrative art.

ENGL 3081-2-3-4-5-6. Seminars in Literature
3-0-3 each. Prerequisites: ENGL 1001-2.
Intensive study of individual writers, movements, periods or themes in literature, with the purpose of developing knowledge in depth, critical independence, and expository skill.

ENGL 3101. Greek Drama in Homeric Context
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Greek drama in context of mythic sources. The shift from epic to tragic world view and the separation of comic from heroic through study of Homer, Aeschylus, Sophocles, Euripides, Aristophanes.

ENGL 3131. The Narrative Art of the Film
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Introduction to major forms of film narrative and to principles used in analyzing and understanding cinematic storytelling.

ENGL 3151. Shakespeare: Comedy and History
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Focuses on Shakespeare's methods and on the concern comedy and history plays have for society as a whole. Major works of Shakespeare's contemporaries are studied as appropriate.

ENGL 3152. Shakespeare: Tragedy and Romance
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Focuses on Shakespeare's methods and on the theme of the suffering individual, sacrificed and triumphant. Major works of Shakespeare's contemporaries are studied as appropriate.

ENGL 3161. Science Fiction
3-0-3. Prerequisites: ENGL 1001-2.
Study of selected works of science fiction, with special emphasis on the relationship of their ideas to those of mainstream fiction, science, politics, and history. Seminars, reports, papers.

ENGL 3181. Social Issues in Drama
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Brings a concern with theme or issue to bear on a collection of plays chosen for their social context as well as their aesthetic achievement.

ENGL 3201. American Fiction
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Focuses on novels that reflect American reactions to materialism and idealism, to individual freedom and social responsibility, and to the continuing struggle for the American Dream.

ENGL 3203. American Drama
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Treats a wide range of typically American themes and motifs in the work of America's major dramatists. Themes range from the moral consequences of Puritan repression to the conflict between materialism and idealism.

ENGL 3205. American Poetry
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Treats themes such as the Puritan outlook, American optimism, and the American response to nature as these

themes are presented by nineteenth- and twentieth-century poets.

ENGL 3221. Major Figures in Nineteenth-century American Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Concentrates on the works of Poe, Emerson, Hawthorne, Melville, and other writers in the American Renaissance.

ENGL 3225. The Southern Renaissance
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Investigates this major twentieth-century literary movement, which treated the history of the South in poetry, essays, and novels.

ENGL 3227. Contemporary Southern Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Examines the ways contemporary Southern writers such as Eudora Welty and Alice Walker view the South, its people, changing values, and social issues.

ENGL 3251. Hemingway and His Contemporaries
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Examines the works of Ernest Hemingway and other major writers of the 1920s as they dramatize the shattering effect of World War I and offer perspectives on the modern world that emerge in the postwar years.

ENGL 3401-2. The Western Traditions I, II
3-0-3. Prerequisites: ENGL 1001-2.
Great works of ancient and modern literature representing the dominant traditions of Western civilization, the classical and the Judeo-Christian. Courses need not be taken in sequence.

ENGL 3411-2. Arts and Ideas I, II
3-0-3. Prerequisite: ENGL 1001-2.
Major ideas of Western culture expressed in literature and other art forms—painting, sculpture, architecture, and music. Courses need not be taken in sequence.

ENGL 3461. The Old Testament in the Western Tradition
3-0-3. Prerequisites: ENGL 1001-2.
Examines selected Old Testament literature, with special emphasis on man's continuing efforts to define deity, society, and self.

ENGL 3462. The New Testament in the Western Tradition
3-0-3. Prerequisites: ENGL 1001-2.
Examines selected New Testament literature, with special emphasis on man's continuing efforts to define deity, society, and self.

ENGL 3483. The Concept of Humanism
3-0-3. Prerequisites: ENGL 1001-2.
Examines the celebration of the place of the individual in the cosmic order in representative literary and visual artists from the Renaissance to the twentieth century.

ENGL 3501. Poetry Writing
3-0-3. Prerequisites: ENGL 1001-2.
Intensive work in the composition of poetry. Conducted as a seminar/tutorial.

ENGL 3502. Fiction Writing
3-0-3. Prerequisites: ENGL 1001-2.

Intensive work in composition of fiction. Conducted as a seminar/tutorial.

ENGL 3786. The Immigrant Experience
3-0-3. Prerequisites: ENGL 1001-2, HIST 1001 or 1002.
The history and literature of immigrant/ethnic groups such as English, Blacks, Irish, Germans, Asians, southern and eastern Europeans, Hispanics; exploring Old World reasons for emigrating, New World reactions, assimilation, bigotry, restrictive immigration policies, the World War II relocation camp experience, alienation, the American Dream fulfilled. Lectures and papers.

ENGL 3881-2-3. Special Topics in the Western Tradition
3-0-3 each. Prerequisites: ENGL 1001-2, 2401.
Study of special topics of current interest in Western literature, art, culture, and ideas.

ENGL 4015. Advanced Public Speaking in Business and Industry
3-0-3. Prerequisites: ENGL 3015, 3020. Does not carry humanities credit.
Focuses on oral technical briefings and the dynamics of panel and committee leadership. Practice in the use of visual aids in oral presentation.

ENGL 4020. Advanced Technical Writing
3-0-3. Prerequisites: ENGL 1001-2, 3020. Does not carry humanities credit.
Applies principles of document design, of readability, and of audience analysis to the writing of longer technical documents, such as proposals, feasibility studies, and scientific articles. Seminar.

ENGL 4042. Studies in Drama
3-0-3. Prerequisites: ENGL 1001-2.
Intensive analysis of selected plays, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

ENGL 4081. Man and Himself
3-0-3. Prerequisites: ENGL 1001-2.
Intensive study of works of modern literature that treat the theme of man and himself.

ENGL 4082. Man and Society
3-0-3. Prerequisites: ENGL 1001-2.
Intensive study of works of modern literature that treat the theme of man and society.

ENGL 4083. Current Issues
3-0-3. Prerequisites: ENGL 1001-2.
Intensive study of works of modern literature that treat selected issues of concern.

ENGL 4132. Studies in Film
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Examines in depth a theoretical issue in film criticism.

ENGL 4755. Sex Roles: Their Development and Cultural Influence
3-0-3. Prerequisites: ENGL 1001-2.
Psychological principles, legal facts, and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current, and future. Readings, lectures, discussions, and invited panelists will be utilized.

ENGL 4801-11-21. Special Topics
1-0-1. Prerequisite: consent of the Department.
Study of special topics of current interest in the humanities.

ENGL 4803-13-23. Special Topics
3-0-3. Prerequisites: ENGL 1001-2.
Study of special topics of current interest as reflected in selected literary works.

ENGL 4833. Special Topics in American Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Study of special topics of current interest.

ENGL 4843. Special Topics in Southern Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Study of special topics of current interest.

ENGL 4901-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of the Department. Does not carry humanities credit.
Study of specialized aspects of literature and language selected on basis of current interest.

ENGL 6023. Seminar in Technical Communication
3-0-3. Prerequisite: graduate standing or consent of Department.
Series of intensive writing and editing projects for graduate students who need to communicate technical information effectively.

School of Geophysical Sciences
Established in 1970

Director and Professor—C. S. Kiang; *Associate Director and Associate Professor* —J. M. Wampler; *Professors*—William L. Chameides, George Chimonas, Douglas D. Davis, Franco Einaudi, Gerald W. Grams, C. G. Justus, L. Timothy Long, R. G. Roper, Charles E. Weaver, H. L. Windom; *Associate Professors*—Kevin C. Beck, Philip M. Carrion, Robert P. Lowell, E. Michael Perdue, Charles O. Pollard, Jr.; *Assistant Professors*—R. E. Habermann; *Principal Research Scientists*—Fred N. Alyea, Derek M. Cunnold, John Hall; *Senior Research Scientists*—John O. Bradshaw, Edward M. Patterson; *Research Scientist II* —Carlos Cardelino, Alessandro Coletti, A.A. Hassani-Pak, Lonzy Lewis, Michael O. Rodgers, Luther Roland; *Adjunct Faculty: Professors*—Julius Chang, Paul Crutzen, Donald Lenschow, Douglas K. Lilly, David W. Menzel, Wolfgang Seiler; *Associate Professors*—Jackson O. Blanton, Demetrius Lalas, G. Lafayette Maynard, Ronald G. Prinn, Gordon Wallace; *Assistant Professors*

—James L. Harding, Barry Huebert; *Part-time Instructor*—James W. Erwin.

General Information
The School of Geophysical Sciences offers graduate study programs for those interested in understanding the earth and the physical environment. The programs lead to the degrees Master of Science and Doctor of Philosophy. The term "geophysical sciences," in the broadest sense, includes both physical and chemical studies of the earth, its waters, and its atmosphere. These studies provide basic information for assessing the earth's resources and the evolution of the environment.

Persons with a bachelor's degree in geology, meteorology, atmospheric science, chemistry, physics, mathematics, biology, or engineering may enter the graduate program. The program of study for each student will be tailored to accommodate his or her background and interests.

Present areas of specialization include geophysics, geochemistry, mineralogy, sedimentology, environmental geology, atmospheric dynamics, atmospheric physics, atmospheric chemistry, and physical meteorology. Students carry out interdisciplinary studies in areas such as crystallography (crystal physics), hydrogeology, engineering geology, nuclear geochemistry, organic geochemistry, environmental studies, and energy-meteorology relationships.

The School conducts research and study in oceanography in cooperation with the staff of the Skidaway Institute of Oceanography at Savannah, Georgia. Students who specialize in oceanography conduct their thesis research at Skidaway after completing course work at Georgia Tech.

Atmospheric Sciences
A unique program in atmospheric sciences, combining the elements of atmospheric chemistry, atmospheric dynamics, and physical meteorology, was added to the programs of the School of Geophysical Sciences in the late 1970s. Graduate programs leading to the existing M.S. and Ph.D. degrees in geophysical sciences were approved for stu-

dents specializing in the atmospheric sciences. Because the atmospheric sciences are an integral part of the geophysical sciences, descriptive information about the atmospheric sciences program is included with information about the other geophysical science programs (see General Information above).

The program in atmospheric sciences, which is interdisciplinary and multidisciplinary, is an important element in the overall academic and research effort in environmental studies on the Georgia Tech campus. With increasing awareness of the need for environmental research and planning in both government and industry, the demand is growing for graduates with the background offered by this program.

Undergraduate Program
The geophysical sciences are multidisciplinary with a strong dependence on the basic physical sciences, engineering, and mathematics; therefore, undergraduate students interested in the geophysical sciences should work toward a bachelor's degree in one of these disciplines. An undergraduate enrolled in another Georgia Tech school may develop a substantial background in the geophysical sciences by proper choice of electives within his or her own degree program. For example, the School of Physics recommends a specific set of upper-level courses for physics majors who are interested in geophysics.

A certificate program is available for students who take a systematic series of courses in the geophysical sciences. Certificates are available for course work in three areas: geochemistry, geophysics, and engineering geology. Listings of the requirements for these certificates are available in the office of the School of Geophysical Sciences.

Master's Degree Programs
The School tailors programs of study to the background and interests of each student entering the School of Geophysical Sciences. In order to pursue the courses that may be accepted as part of a graduate study program in geophysical sciences, students will need a background that includes a minimum of one

year of university-level courses in mathematics, chemistry, and physics. Students who enter without this background must take some remedial work without graduate credit.

In order to qualify for the degree Master of Science in Geophysical Sciences, a student must have completed certain undergraduate courses in geophysical sciences and must complete an approved thesis. Students who wish to include more course work in a special technical area may pursue a program of study that does not meet all the requirements for the designated master's degree. Such a program of study, approved by the faculty of the School, will lead to the degree Master of Science.

Graduate students in the School of Geophysical Sciences can qualify under the Multidisciplinary Program in Mineral Engineering by electing certain mining and minerals courses (see the section "Multidisciplinary Programs in Engineering," p. 82, under the description of the College of Engineering in this catalog).

Doctoral Program

The School of Geophysical Sciences is the principal academic unit at Georgia Tech dealing with resources and environmental problems. Since the School has only a graduate program, there is a concentration of effort on research and graduate education. The School is committed to the development of nationally recognized research programs in which a majority of the graduate students will be pursuing the doctoral degree.

Persons with a strong background in the basic sciences and mathematics, who show a capability for high achievement in research in the geophysical sciences, may enter the doctoral program. A wide range of individual programs is available, owing to the multidisciplinary nature of the geophysical sciences.

Courses of Instruction

GEOS 1000. Introduction to Earth Science
3-0-3.
   A survey of planetary science, atmospheric science, and oceanography, giving general insight into the nature of man's environment.

GEOS 2100. General Geology
3-0-3. Corequisites: CHEM 1102 or 1112, PHYS 2121.

Introduction to minerals, rocks, and soils. Structure and evolution of the earth's surface features, crust, and interior.

GEOS 2102. General Geology Laboratory
0-3-1. Corequisite: GEOS 2100.
   Exercises on minerals, rocks, topographic maps, and geologic maps.

GEOS 2750. Physics of the Weather
3-0-3.
   An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed. Cross-listed as PHYS 2750.

GEOS 3000. Earth Resources
3-0-3. Prerequisite: GEOS 2100.
   A study of Earth's physical resources—fresh water, land (soils), minerals, and fuels—emphasizing the geologic origin, geographic distribution, and future availability of the resources.

GEOS 3100. History of the Earth
3-3-4. Prerequisites: GEOS 2102. Winter quarter.
   The physical history of the earth and the history of life on the earth, based on the record preserved in the rocks of the earth's crust.

GEOS 3400. Mineralogy
3-3-4. Prerequisite: GEOS 2102 or consent of the School. Fall quarter.
   Crystal bonding and symmetry, crystal structure and crystal chemistry, application to geologically important minerals. Laboratory devoted to crystallography, hand specimen identification, X-ray diffraction.

GEOS 3410. Optical Mineralogy
1-3-2. Prerequisite: GEOS 3400.
   A brief introduction to the use of the polarizing microscope for the identification and study of rocks and minerals.

GEOS 4150. Petrology of the Sedimentary Rocks
2-3-3. Prerequisite: GEOS 3410. Winter quarter.
   Texture, composition, and structure of sediments and sedimentary rocks, sedimentary processes (hydraulics and aqueous geochemistry), analysis of sedimentary environments.

GEOS 4200. Structural Geology
3-3-4. Prerequisite: GEOS 2102. Spring quarter.
   Structures produced by rock deformation during tectonic and metamorphic activity. Primary structural features. The laboratory will include several field trips.

GEOS 4250. Engineering Geology
3-3-4. Prerequisite: GEOS 2100. Winter quarter, alternate years.
   Interpretation and presentation of geologic information for engineering use. Properties of geologic materials. Applications of geology to engineering and construction.

GEOS 4300. Introduction to Physical and Chemical Oceanography
3-0-3. Prerequisite: GEOS 2100 or consent of the School.
   Ocean geometry, physical properties of sea water, water movements and energy fluxes, sediments, marine geochemistry, marine geophysics and tectonics, ocean history.

GEOS 4500. Introduction to Geophysics
3-0-3. Prerequisite: GEOS 2100. Fall quarter.
   General survey of terrestrial geophysics. Topics discussed include the earth's seismicity, internal structure, shape, gravity, magnetic field, paleomagnetism, heat flow, and global tectonics.

GEOS 4550. Applied Geophysics
3-3-4. Prerequisites: GEOS 2100, PHYS 2123.
   Theory of electrical, magnetic, gravity, seismic refraction and reflection exploration methods. The laboratory provides exercises in instrumentation and data interpretation.

GEOS 4551. Seismic Reflection Methods in Exploration Geophysics
3-0-3. Prerequisite: MATH 2309 or consent of the instructor. Fall quarter.
   Seismic wave propagation, ray theory, and refraction data interpretation. Seismic reflection data acquisition and interpretation techniques. Application of seismic data to the search for oil.

GEOS 4552. Potential Methods in Exploration Geophysics
3-0-3. Prerequisites: GEOS 2100, MATH 2309, or consent of the instructor. Winter quarter.
   Potential theory, the earth's gravitational field, reduction of gravity data. Modeling gravity anomalies. Magnetic field of the earth and magnetic anomalies. Techniques of electrical methods.

GEOS 4600. Introduction to Geochemistry
3-3-4. Prerequisites: GEOS 2100, CHEM 2113. Fall quarter.
   Distribution and behavior of the chemical elements and natural compounds in the earth, its waters, and its atmosphere. Application of chemical principles to geologic processes.

GEOS 4650. Introduction to Atmospheric Sciences
3-0-3. Prerequisites: CHEM 1102, MATH 2309, PHYS 2123, thermodynamics. Fall quarter.
   Introduction to atmospheric physics, chemistry, and dynamics, with emphasis on the interdisciplinary nature of atmospheric science, and man's interaction with the environment.

GEOS 4801-2-3-4-5. Special Topics
1-0-1, 2-0-2, 3-0-3, 4-0-4, 5-0-5 respectively.

GEOS 4900. Special Problems
Credit hours to be arranged.

GEOS 6049. Geophysics I—Deformation of Earth Materials
3-0-3. Prerequisite: consent of the School. Winter quarter.
   Theoretical survey of the elastic and inelastic behavior of the earth's materials and implications for tectonics, heat flow, and the earth's interior.

GEOS 6051. Geophysics II—Gravity
3-3-4. Prerequisite: consent of the School. Spring quarter.
   An intense theoretical survey of terrestrial geophysics. Topics include potential theory, shape of the earth, and physical geodesy.

GEOS 6052. Geophysics III—Geomagnetism and Paleomagnetism
3-0-3. Prerequisite: GEOS 6051 or consent of the School.
   Topics include magnetohydrodynamics, origin and description of the earth's magnetic field, rock magnetism, remanent magnetism, geophysical evidence for global tectonics and tectonic mechanisms.

GEOS 6100. Clay Mineralogy
3-0-3. Prerequisite: consent of the School. Fall quarter.
   The composition and structure of clay minerals, physical and chemical properties, X-ray identification, geologic distribution and significance, origin.

GEOS 6110. Advanced Clay Mineralogy
2-3-3. Prerequisite: GEOS 6100. Winter quarter.
   Clay-water relations; cation exchange; effects of crystal structure and composition on physical and chemical properties, X-ray, electron microscope, and other techniques.

GEOS 6150. Sedimentary Geology
3-3-4. Prerequisite: GEOS 3410. Winter quarter.
   Composition, texture, and structure of sediments and sedimentary rocks, sedimentary processes, diagenesis, environments of deposition, stratigraphy of sedimentary rocks.

GEOS 6160. Stratigraphy and Sedimentation
3-0-3. Prerequisite: GEOS 6150. Spring quarter.
   Continuation of GEOS 6150 with emphasis on sedimentary environments, recent and ancient. Principles of correlation, stratigraphic mapping, and stratigraphic analysis.

GEOS 6210. Global Tectonics
3-0-3. Prerequisite: GEOS 4200.
   A seminar that explores the recent revolution in understanding the dynamic behavior of the earth through readings from the literature and student presentations.

GEOS 6250. Advanced Engineering Geology
3-0-3. Prerequisite: GEOS 4200 or consent of the instructor. Winter quarter, alternate years.
   Application of the principles of engineering geology to problems in civil engineering, with emphasis on specific cases of particular interest.

GEOS 6300. Principles of Physical Oceanography
3-0-3. Prerequisite: consent of the School.
   Temperature, salinity, and density in the oceans. Dynamics of ocean currents. Theory of ocean waves. Selected topics with application to coastal and estuarine circulation.

GEOS 6310. Principles of Chemical Oceanography
3-0-3. Prerequisite: CHEM 3412, GEOS 4300, or consent of the School.
   Brief overview of the chemistry of sea water and marine sediments. Detailed discussion of selected topics.

GEOS 6400. Igneous Petrology
3-3-4. Prerequisite: GEOS 6425. Winter quarter, alternate years.
   Microscopic study, classification, physical chemistry, and evolution of igneous rocks.

GEOS 6425. Geologic Phase Diagrams
3-0-3. Prerequisite: CHEM 2113, GEOS 4600, or consent of the School. Fall quarter.
Practical application of available phase diagrams to problems in metamorphic and igneous petrology. Phase rule is used extensively.

GEOS 6450. Metamorphic Petrology
3-3-4. Prerequisite: GEOS 6425. Winter quarter, alternate years.
Study and classification of chemical and physical changes induced in rocks upon metamorphism. Microscopic laboratory study.

GEOS 6510. Analytical Methods in Geophysics I
3-3-4. Prerequisite: GEOS 6051.
Theory and practice in the application of numerical analysis methods to geophysical data. Topics include information theory in seismology and harmonic analysis of potential data.

GEOS 6520. Analytical Methods in Geophysics II
3-3-4. Prerequisite: consent of the instructor.
Hankel transforms and applications, electrical soundings. Propagation of plane waves in nonhomogeneous media, the W.K.B.J. approximation, magneto-telluric soundings. Radiation of a dipole over a layered conducting half space, electromagnetic soundings.

GEOS 6550. Observational Seismology
3-3-4. Prerequisite: GEOS 4500.
A study of the nature of earthquake motion and the damage it causes. The laboratory provides exercises in the interpretation of seismograms.

GEOS 6560. Theoretical Seismology
3-3-4. Prerequisites: MATH 4320, 4581, 4582, GEOS 6550.
Theory of elastic wave propagation in the earth. Topics include reflection of waves, surface waves, and Cagniard theory of body waves.

GEOS 6600. Aqueous Geochemistry
3-0-3. Prerequisite: CHEM 3412, GEOS 2100, or consent of the School. Winter quarter.
Reactions of minerals in waters on or near the surface of the Earth.

GEOS 6610. Organic Geochemistry
3-0-3. Prerequisite: CHEM 3313 or consent of the School. Spring quarter, alternate years.
Origin and transformation of organic matter in the carbon cycle, with emphasis on humic substances, kerogens, and fossil fuels.

GEOS 6620. Nuclear Geochemistry
3-0-3. Prerequisites: PHYS 2123, GEOS 3400. Spring quarter, alternate years.
Nuclear reactions and radioactive decay in nature. Geochemistry of radionuclides. Age measurements based on radioactive decay. Abundance variations of radiogenic and cosmogenic stable nuclides.

GEOS 6625. Stable Isotope Geochemistry
2-0-2. Prerequisites: CHEM 2113, GEOS 3400. Spring quarter, alternate years.
Variations in isotopic composition of the elements owing to isotope effects in natural physical and chemical processes. Application of isotope ratio measurement to geochemistry, hydrology, oceanography, and paleoclimatology.

GEOS 6750. Introductory Diffraction Studies
2-6-4. Prerequisite: consent of the School.
Introductory theory and practice of the most widely applicable X-ray and neutron diffraction techniques. Identification, lattice parameters, textures, line breadth, and crystal orientation. Cross-listed with PHYS 4755.

GEOS 6764. Ocean Acoustics
3-0-3. Prerequisite: MATH 4582. Recommended: GEOS 4300, AE 6760.
Propagation of sound waves in the ocean. Topics selected from stress-strain relationships, asymptotic ray theory, propagation in shallow and deep water, irregularities of the media and boundaries, sonar arrays. Cross-listed with ME 6764, ESM 6764.

GEOS 6791. Atmospheric Turbulence
3-0-3. Prerequisite: GEOS 4650, fluid dynamics.
Introduction to turbulence, turbulent transport of momentum and heat, sources of turbulence in the atmosphere, the dynamics of turbulence, statistical description, correlation functions and the spectral dynamics of turbulence.

GEOS 6792. Air Pollution Meteorology
3-0-3. Pre- or corequisite: GEOS 4650.
Vertical temperature and wind structure, topographic effects, natural removal processes, atmospheric dispersion of stack effluents, air pollution climatology, meteorological management of air pollution.

GEOS 6793. Atmospheric Boundary Layer
3-0-3. Prerequisite: GEOS 6811.
Structure and aerodynamics of atmospheric boundary layer, turbulent transport of contaminants in the environment, stratified and disturbed atmospheric boundary layer, free convection layer, current problems.

GEOS 6810. Introduction to Geophysical Fluids
3-0-3. Prerequisites: basic undergraduate calculus sequence and a course in ordinary differential equations.
The course is designed to introduce the student to the basic concepts of geophysical flows. The theory of flows in a rotating spherical layer is presented; fundamental theorems and their applications in meteorology are described.

GEOS 6811. Dynamic Meteorology I
3-0-3. Prerequisite: GEOS 6810.
Review of the mechanics of motion in the atmospheric shell. Fundamental nondimensional parameters defining geophysical flows. Vorticity equation. Synoptic scale motions in the context of shallow-water theory. Gravity waves, stability criteria, clear air turbulence.

GEOS 6812. Dynamic Meteorology II
3-0-3. Prerequisite: GEOS 6811.
Quasigeostrophic motion in the presence of stratification. General considerations on instability theory, energetics analysis of atmospheric motions. Baroclinic instability. Fronts and frontogenesis. Blocking and barotropic instability.

GEOS 6813. Geophysical Fluid Dynamics
3-0-3. Prerequisite: GEOS 6812.

The objective of the course is to provide as uniform a presentation as possible of the principles and characteristics of the dynamics of the atmosphere and the ocean.

GEOS 6820. Introduction to Atmospheric Chemistry
3-0-3. Prerequisite: MATH 2309 or equivalent. Winter quarter.
Basic chemical principles relating to atmospheric chemistry: electrostatics, atomic structure, chemical bonding, molecular geometry, chemical thermodynamics, chemical reactivity, gas phase kinetics, photochemistry, free radical mechanisms, properties of solutions, homogeneous and heterogeneous kinetics.

GEOS 6821. Atmospheric Chemistry
3-0-3. Prerequisite: GEOS 6820 or advance approval from the instructor. Spring quarter.
Topical areas covered include sources and sinks of natural and anthropogenic tropospheric chemical constituents, tropospheric and stratospheric chemical transformations, large-scale biogeochemical cycles of the elements carbon, sulfur, and nitrogen, and human perturbations to the planetary atmospheric system.

GEOS 6830. Introduction to Physical Meteorology
3-0-3. Prerequisites: MATH 2309, PHYS 3141. Fall quarter.
Fundamental principles of atmospheric physical processes. Hydrostatic equilibrium and static stability; physics of clouds, precipitation, and thunderstorms.

GEOS 6831. Physical Meteorology
3-0-3. Prerequisite: GEOS 6830. Winter quarter.
Radiative transfer in the atmosphere. The atmospheric green-house effect and the earth's energy budget.

GEOS 6915. Synoptic Meteorology
3-0-3. Prerequisite: GEOS 6811.
Terrestrial winds, cyclones and anticyclones, the general circulation of the atmosphere, air masses and fronts, tropical cyclones-hurricanes, weather analysis and interpretation.

GEOS 6921. Atmospheric Chemistry II
1-3-2. Prerequisite: GEOS 6821 or concurrently.
This course is designed to introduce the student to modern instrumental techniques used in obtaining basic information about the chemical properties of the atmosphere. Special emphasis is placed on advanced laser detection methodology. Both laboratory and lecture material will be presented.

GEOS 6922. Chemistry and Physics of Atmospheric Aerosols
3-0-3. Prerequisite: GEOS 6821 or consent of the School.
Chemical and physical properties of natural and anthropogenic atmospheric aerosols. Formation and removal mechanisms involved in various atmospheric sources, sinks, and transformation processes.

GEOS 6927. Photokinetics and Spectroscopy
3-0-3. Prerequisite: GEOS 6821 or equivalent kinetics courses.
This course will examine the spectroscopy of atomic and molecular species as well as the photodynamics and kinetics resulting from photofragmentation processes.

GEOS 6932. Meteorology for Solar and Wind Energy
2-3-3. Prerequisite: GEOS 4650 or concurrently.

Solar radiation instruments, measurement and calibration techniques. Atmospheric attenuation, effects of clouds and turbidity. Meteorological factors of wind energy system design, performance evaluation and siting.

GEOS 6933. Precipitation Processes
3-0-3. Prerequisite: GEOS 6831.
Nucleation and phase changes in the atmosphere, precipitation processes, cloud electrification, artificial modification, application of radar to precipitation.

GEOS 6934. Atmospheric Optics and Radiation Transfer
3-0-3. Prerequisite: GEOS 6830. Spring quarter, alternate years.
Quantitative treatment of radiative transfer in the atmosphere; absorption and scattering by atmospheric molecules and particulates; atmospheric visibility and optical effects.

GEOS 6940. Introduction to Climate
3-0-3. Prerequisite: GEOS 6811.
Physical parameters controlling the climate and general circulation. Diagnostic analysis of present climate. The quasi-geostrophic theory of general circulation.

GEOS 6941. Atmospheric Modeling
3-0-3. Prerequisite: GEOS 6821 or consent of the School.
Application of modern numerical methods to the prediction of atmospheric chemical and physical compositions; specific applications using computer models developed by the students are included.

GEOS 7000. Master's Thesis

GEOS 7911. Upper Atmospheric Dynamics
3-0-3. Prerequisite: GEOS 6811.
The dynamics of the neutral atmosphere in the stratosphere, mesosphere, and lower thermosphere—prevailing winds, jet streams, waves, tides, and turbulence; winter stratwarms, coupling mechanisms.

GEOS 7999. Preparation for the Comprehensive Examination
Credit TBA. Audit only.

GEOS 8011-2-3. Seminar
1-0-1 each. Pass/fail or audit only.
A forum for graduate students in geophysical sciences to present and discuss topics related to their research interests.

GEOS 8102-3. Special Topics
2-0-2, 3-0-3.

GEOS 8111-2-3-4-5. Special Topics
1-0-1, 2-0-2, 3-0-3, 4-0-4, 5-0-5 respectively.

GEOS 8123. Special Topics
3-0-3.

GEOS 8133. Special Topics
3-0-3.

GEOS 8143. Special Topics
3-0-3.

GEOS 8153. Special Topics
2-3-3.

GEOS 8500-1-2. Special Problems
Credit to be arranged.

GEOS 8997. Teaching Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
   For graduate students holding graduate teaching assistantships.

GEOS 8998. Research Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
   For graduate students holding graduate research assistantships.

GEOS 8999. Preparation for Doctoral Dissertation
Credit TBA. Audit only.

GEOS 9000. Doctoral Thesis

School of Information and Computer Science

Established in 1963

Director and Professor—Raymond E. Miller; *Associate Director and Professor*—Lucio Chiaraviglio; *Assistant Director for Research*—Richard A. DeMillo; *Assistant Director for Laboratories*—John F. Passafiume; *Professors*—Richard E. Cullingford, Philip H. Enslow, Jr., Alton P. Jensen (emeritus), Raymond E. Miller, Morris D. Prince (part-time), Vladimir Slamecka, Pranas Zunde; *Associate Professors*—William F. Appelbe, Albert N. Badre, Nancy D. Griffeth, Janet L. Kolodner, Richard J. LeBlanc, Jr., Gary L. Peterson, Philip J. Siegmann, Robert M. Siegmann (part-time); *Associate Professor-Librarian*—Frances E. Kaiser (adjunct); *Assistant Professors*—Mustaque Ahamad, Mostafa H. Ammar, James E. Burns, Partha Dasgupta, John J. Goda, Jr., Oliver C. Ibe, Edward R. Omiecinski, Umakishore Ramachandran, Jon S. Rugaber (part-time), H. Venkateswaran, Gopalakrishnan Vijayan; *Senior Research Engineer*—W. Michael McCracken; *Research Scientists II*—William A. Baird, K. N. King, Uliana Lancaster, Rhonda J. Martin, William O. Putnam, Eugene H. Spafford; *Research Scientists I*—Dany S. Guindi, Ronald R. Hutchins, Win E. Strickland; *Part-time Instructors*—Leonora J. Brooke, Jyoti Mathur.

General Information
The goals of the discipline of information and computer science are to further develop a fundamental science for computing proc-esses, to enhance human problem-solving ability by designing novel information processing systems, and to expand the functions of such systems into new areas of society. During the last decade, computers have become indispensable in science, engineering, management, education, and other professions. Many believe that in the near future, information processing will become the nation's largest industry and that its disciplines will be centrally important to society.

Georgia Tech's School of Information and Computer Science reflects this growth and potential. It was established in 1963 with the sponsorship of the National Science Foundation. Today, the School is one of the largest graduate departments of the Institute and is among the largest computer science schools in the United States. It offers the bachelor's, master's, and doctoral degrees in information and computer science for professional and research careers in many areas of specialization.

The School's research computer systems include a VAX 11/780, a cluster of three VAX 11/750s, a Data General MV/10000, eight AT&T 3B2s, and numerous smaller systems. Many of these connect to the School's local network, which is linked to a campuswide network that provides dial-up access to any of the systems connected to it. The VAX 11/780 allows access to CSNET, which in turn permits the use of ARPANET, providing a means of direct communication with computer science researchers across the nation.

The School operates several instructional laboratories. One is built around a Tektronix 4115 system, twelve Tektronix 4107 graphics terminals, and four color ink-jet printers; the others consist of two thirty-unit PC classrooms connected to an IBM 4361 through three IBM Series/1 systems; an artificial intelligence laboratory containing a dozen XEROX 1108 Dandelion work stations; and a classroom/laboratory containing ten AT&T 3B2 systems.

The Office of Computing Services operates four CDC CYBER 180 systems (models 810, 830, 855, and 990), an IBM 4381, two AT&T 3B20s, fifteen AT&T 3B2s (in a classroom with thirty AT&T 5620 dot-mapped terminals), and a Pyramid 90X system. The Office of Computing Services also operates Xerox 8790 and 9700 laser printers. The School is a major user of the Pyramid system, which supports both System V UNIX and Berkeley UNIX.

In addition to the general-purpose computing equipment listed above, the School has many specialized systems. For graphics research there is an Adage 3000 graphics processor and an Evans and Sutherland PS 300 graphics system. The School's five Symbolics 3600 LISP machines and two Xerox LISP work stations support artificial intelligence work. For education and research in computer networking and communications systems, the School has more than $2 million worth of switching, transmission, and test equipment, including three Northern Telecom SL-10 packet switches, the largest single concentration of these switches in the United States.

Details of the academic and research programs of the School are described in brochures available upon request.

Undergraduate Program
The undergraduate program, established in 1972, is accredited by the Computing Sciences Accreditation Board, Inc. (CSAB). CSAB was established in 1984 by the Association for Computing Machinery and the IEEE Computer Society. The ICS program was among the first group of twenty-three programs to be accredited. The program leads to the designated degree Bachelor of Science in Information and Computer Science. The program provides a basic education in computer science leading to two objectives. The first is the acquisition of marketable knowledge and skills for professional design and development careers in areas such as computer systems, programming systems and languages, networks, artificial intelligence, software engineering, and databases. The second is preparation for graduate work in information and computer science.

In addition to the standard four-year plan, a five-year cooperative plan is offered for students who wish to combine their education with industrial experience.

The undergraduate program requires a total of 197 credit hours for graduation. With the exception of free electives, all ICS B.S. degree course work must be taken on a letter-grade basis. Up to twelve hours of free electives may be taken on a pass/fail basis. See page 39 for additional pass/fail restrictions.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
ICS 1000 Information and Society	1-0-1	.....	.....
ICS 1001 Computing Facilities	0-3-1	.....	.....
ICS 1410-1 Programming Concepts, Standards, and Methods I, II	.....	3-3-4	3-3-4
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2101, 2201, 2301, or 2401	.....	.....	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Laboratory Science Electives	4-3-5	4-3-5	.....
Physical Education (requirements, p. 253)	.....	.....	3-0-3
TOTALS	13-6-15	15-6-17	14-3-15

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
ICS 2201 Data Structures	.....	3-3-4	.....
ICS 2250 Technical Information Resources	1-0-1	.....	.....
ICS 2301 File Processing	.....	.....	3-3-4
ICS 2601-2 Computer Organization and Programming I, II	.....	3-3-4	3-3-4
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3012 Applied Combinatorics	3-0-3	.....	.....
PHYS 2121 Particle Dynamics	4-3-5	.....	.....

	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	.....	4-3-5	.....
PHYS 2123 Optics and Modern Physics	.....	.....	4-3-5
Humanities/Social Sciences/Modern Languages Electives	3-0-3	.....	3-0-3
TOTALS	16-3-17	15-9-18	13-9-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ICS 3155 Introduction to Theory of Computing I	.....	3-0-3	.....
ICS 3301 Introduction to Software Development	3-3-4	.....	.....
ICS 3361 Introduction to Artificial Intelligence	.....	.....	3-3-4
ICS 3410 Survey of Programming Languages	.....	3-3-4	.....
ICS 3602 Computer Organization and Programming III	3-3-4	.....	.....
ICS 4155 Introduction to Theory of Computing II	.....	.....	3-0-3
ENGL 3020 Technical Writing	.....	3-0-3	.....
MATH 3215 Problems in Probability and Statistics	5-0-5	.....	.....
Humanities/Social Sciences/Modern Languages Electives	3-0-3	6-0-6	3-0-3
Free Electives	.....	.....	6-0-6
TOTALS	14-6-16	15-3-16	15-3-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ICS Areas of Specialization Electives	X-X-9	X-X-9	X-X-6
Non-ICS Areas of Specialization Electives	3-0-3	3-0-3	3-0-3
Humanities/Social Sciences/Modern Languages Electives	3-0-3	3-0-3	3-0-3
Free Electives	3-0-3	3-0-3	3-0-3
TOTALS	X-X-18	X-X-18	X-X-15

ELECTIVES

Humanities Electives
ENGL 1001-2 and three credit hours of 2000-level English literature (2101, 2201, 2301, or 2401) apply toward satisfaction of the eighteen-hour humanities requirement stated in "Information for Undergraduate Students," pp. 41-42.

Social Sciences Electives
See "Information for Undergraduate Students," pp. 41-42. for a list of courses that satisfy the eighteen-hour social sciences requirement. All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1250 or 3200 fulfill this requirement and apply toward satisfaction of the eighteen-hour social sciences requirement. Other recommended social sciences electives include ECON 2000, ECON 2001, PSY 3303, and PSY 3304. The psychology courses are prerequisite to ICS 4753 and 4754.

Laboratory Science Electives
This requirement may be met by scheduling CHEM 1101 and 1102, or BIOL 1110, 1111, and 1112. Hours for biology in excess of ten may be used for free electives.

Physical Education
This requirement may be met by scheduling either PE 1040 or PE 1061. A maximum of six credit hours of physical education may be applied toward the bachelor's degree. Credit hours in excess of three may be used as free electives.

Free Electives
Free elective courses may be taken any time during the course of study. If basic ROTC is selected to satisfy six of these credit hours, it must be scheduled beginning the first quarter of the freshman year. Six hours of basic ROTC and nine hours of advanced ROTC may be used as free elective credit toward the bachelor's degree. Only three credit hours of physical education may be used as free electives. No course that covers the same material as other courses in a student's plan of study can be used as a free elective.

ICS Areas of Specialization Electives
A student will be required to complete two areas of specialization and select courses from the advanced elective courses for a minimum of twenty-four hours. Courses satisfying this requirement must be approved by the School.

Non-ICS Areas of Specialization Electives
The non-ICS area of specialization must be recommended and approved by the School.

Master's Program
The Master of Science program prepares students for professional careers in technical and technical-managerial positions and for continued studies at the doctoral level. A student may earn the ICS M.S. degree by either completing fifty quarter hours of approved course work or thirty-three hours of approved course work and a thesis, credited as follows:

Without Thesis
Total Course Credit Hours	50
Minimum Credit Hours in ICS	36
Minimum Credit Hours (6000/8000 Level)	35
Minimum Credit Hours (6000/8000 Level) in ICS	27

With Thesis
Total Credit Hours	50
Thesis Hours (7000)	17
Total Course Credit Hours	33
Minimum Credit Hours in ICS	24
Minimum Credit Hours (6000/8000 Level) in ICS	18

Within the fifty total credit hours, students must include ICS 6155, 6410, 6420, 6450, 6620, and 6751 as part of their approved program of study unless they have previously taken courses that cover this material.

Undergraduate courses required for the ICS B.S. degree may not be used toward the ICS master's degree. In addition, no graduate credit will be given for 3XXX courses or lower-level courses.

With the exception of thesis research, students must take all ICS M.S. degree course work on a letter-grade basis. The maximum total credit hours of ICS 85XX (Special Problems) that may be applied toward the ICS M.S. degree is five. Additional degree requirements as specified by the Institute are listed in the section, "Information for Graduate Students."

Students applying for admission to the master's degree program must have earned a bachelor's degree from an accredited institution, preferably in computer science. Students lacking a strong background in computer science must be prepared to do substantial remedial work in order to qualify for full graduate standing. The M.S. degree program begins in the fall quarter of each academic year.

Doctoral Program
The doctoral program in the School of Information and Computer Science prepares exceptionally qualified individuals for research careers. Graduates receive the degree of Doctor of Philosophy for performance of original research resulting in a significant contribution to the discipline's body of knowledge.

The doctoral program has three phases that normally require a minimum of three years to complete. At the end of the first phase, the student must be able to demonstrate basic knowledge of a spectrum of subject areas in computer and information science, as well as a high research potential. The second phase culminates in the formulation of a dissertation research proposal. Research and the dissertation defense complete the program.

Students applying for admission to the doctoral program should offer evidence of exceptional scholastic ability, intellectual creativity, research motivation, and a strong background in computer science. Students lacking such background must be prepared to do substantial remedial work in computer science before attaining full graduate standing.

Graduate Cooperative Program
The School participates in the Graduate Cooperative Program, which is administered by the Office of Graduate Studies and

Research. Details of the program are stated in the section "Information for Graduate Students."

Research Opportunities

Active participation in research is an integral part of every student's education. The School conducts research in a broad range of fields that come to focus in three main areas: artificial intelligence, distributed processing and networks, and software engineering. Research in distributed operating systems, distributed programming languages and environments, communication systems, human factors in computer systems, database systems, information systems, advisory and natural language systems, software testing systems, theory, and many others in various ways currently dovetail in the mentioned main areas. Students have excellent opportunities to engage in research suited to their talents and interests. Dr. Richard A. DeMillo, professor and assistant director for Research for the School, is director of the Software Engineering Research Center of Georgia Tech. The mission of the Center is to plan, conduct, and support software engineering research on an Institute-wide basis as well as to make software engineering technology available for use in a broad spectrum of industrial, business, and government activities.

The School has a close collaborative relation with the Center, which is conveniently cohoused with the School. Its presence provides the School and its graduate students with excellent research opportunities in software engineering. The Georgia Tech Research Institute provides additional research opportunities to graduate students in computer systems and a broad selection of application areas. The School, the Software Engineering Research Center, and the Georgia Tech Research Institute offer graduate research assistantships to qualified students.

Service to Other Disciplines

Computing competence is an indispensable skill for many professions; consequently, quality education in science, engineering, and management increasingly emphasizes formal instruction in computing. The School of Information and Computer Science offers all Georgia Tech students, regardless of major, elective courses that provide students with the opportunity to gain competence necessary for their future professions.

Courses of Instruction

ICS 1000. Information and Society
1-0-1.
The history and future of the information industry. Career paths in information and computer science.

ICS 1001. Computing Facilities
0-3-1.
Introduction to the equipment and facilities of the School and the Office of Computing Services. Emphasis on the effective use of the time-sharing systems.

ICS 1410. Programming Concepts, Standards, and Methods I
3-3-4.
First course in problem solving using computers. The concept and notation of algorithms. Problem analysis, development of algorithms, and their implementation in a procedure-oriented language (Pascal).

ICS 1411. Programming Concepts, Standards, and Methods II
3-3-4. Prerequisite: ICS 1410.
A continuation of the development of discipline in program design and implementation and in programming style. Credit not allowed for both ICS 1411 and 2101.

ICS 1700. Digital Computer Organization and Programming
3-0-3.
Algorithmic processes of problem solving, properties of algorithms, development of algorithms for the solution of numerical and nonnumerical problems. The FORTRAN programming language. No credit for ICS majors.

ICS 2101. Computer Programming
3-3-4. Prerequisite: ICS 1700 or equivalent.
The programming language PASCAL is introduced. Extensive use is made of programming examples and assignments to develop effective programmming skill. Credit not allowed for both ICS 1411 and 2101.

ICS 2201. Data Structures
3-3-4. Prerequisites: ICS 1411 or 2101, MATH 1308, 3012.
Logical data structures and their representation. Abstract data types. Processes on data structures, with emphasis on lists and trees.

ICS 2250. Technical Information Resources
1-0-1.
Introduction to the literature and information services of science, engineering, and management. Effective uses of the Georgia Tech library.

ICS 2301. File Processing
3-3-4. Prerequisite: ICS 2201.
Introduction to concepts and techniques for manipulating data on bulk storage devices.

ICS 2601. Computer Organization and Programming I
3-3-4. Prerequisite: ICS 1411 or 2101.
Introduction to computer organization, machine language programming, and assembly systems. Assembly language programming techniques.

ICS 2602. Computer Organization and Programming II
3-3-4. Prerequisites: ICS 2201, 2601, PHYS 2122.
Intermediate treatment of computer organization and machine programming. Input/output processing memory and processor structures, and interfacing. Basic computer logic design, gate minimization, cost evaluation, and combinatorial circuits.

ICS 3155. Introduction to Theory of Computing I
3-0-3. Prerequisite: MATH 3012.
Study of fundamental concepts in the formal theory of automata emphasizing finite state machines. Turing machines and computational power of machines.

ICS 3301. Introduction to Software Development
3-3-4. Prerequisites: ICS 2301, 3602.
Introduction to current techniques used in large-scale software development. Topics include requirements analysis, functional specification, systems design, implementation testing, and maintenance.

ICS 3361. Introduction to Artificial Intelligence
3-3-4. Prerequisite: ICS 3410.
Introduction to cognitive modeling, automatic problem solving, natural language processing, machine perception, and robotics.

ICS 3400. Automatic Data Processing
2-3-3. Prerequisite: ICS 1410 or 1700 or equivalent.
Development of algorithms for the solution of business-oriented problems. File structure organization and processing on different types of storage devices. The COBOL programming language.

ICS 3410. Survey of Programming of Languages
3-3-4. Prerequisite: ICS 2201.
A study of the fundamental features of programming languages using the languages PASCAL, Modula-2, FORTRAN, LISP, APL, and Ada as examples.

ICS 3602. Computer Organization and Programming III
3-3-4. Prerequisite: ICS 2602.
Basic treatment of computer system software, including operating systems, assemblers, macroprocessors, compilers, interpreters, linkers, and loaders. Sequential logic, microprocessor design and programming.

ICS 4120. Introduction to Information Processes I
3-0-3. Prerequisites: MATH 3012, 3215.
Explication of the information concept and its properties. Statistical theory of syntactic communication: information sources, information transmission, channel capacity and efficiency, coding, noisy communication channels.

ICS 4121. Introduction to Information Processes II
3-0-3. Prerequisites: MATH 3012, 3215.
Computer methods of clustering, identification, systematization, and pattern recognition; empirical data

processing, choice of measurement, feature selection, data reduction, optimality criteria; analysis of algorithms, applications.

ICS 4136. Problem Solving
3-0-3. Prerequisite: ICS 3361.
General approaches to problem solving, with emphasis on methods and techniques of formalizing intuitive heuristics. Structure of problems and goals, generation of alternatives. Incomplete information.

ICS 4155. Introduction to Theory of Computing II
3-0-3. Prerequisites: ICS 22201, MATH 3012.
Introduction to the mathematical analysis of computer algorithms, correctness, complexity, asymptotic lower bounds, efficient data structures, and combinatorial algorithms. NP-complete problems.

ICS 4250. Literature of Science and Engineering
2-3-3. Prerequisite: ICS 2250.
Study of the reference and bibliographic sources of scientific, engineering, and management literature, emphasizing strategies of manual and computer searching. Bibliographic project in student's discipline.

ICS 4344. Natural Language Understanding by Computer
3-6-5. Prerequisite: ICS 3361.
Methodologies for designing systems that comprehend natural language. Topics include lexical analysis, parsing, interpretation, and generation of sentences; semantic representation, organization of knowledge, and inference mechanisms.

ICS 4351. MIS Methodology
3-0-3.
Methodology for the design and implementation of management information systems in industrial, business, and governmental organizations. Feasibility studies; system development, implementation, and evaluation. Project management.

ICS 4370. Information Storage and Retrieval
3-0-3. Prerequisites: ICS 2602, MATH 3215.
Computer-aided organization and retrieval of bibliographic and natural-language information. Topics include statistical, syntactic, and logical analysis of information content, evaluation of retrieval effectiveness.

ICS 4380. Data Communications
3-0-3. Prerequisite: ICS 3602.
An introduction to data communications for computers and computer terminals, including communications media, codes, data transmission, multiplexing, communications software, protocols, switching, and simple networks.

ICS 4381. Principles of Data Communication Systems
2-6-4. Prerequisite: ICS 4380.
A detailed coverage of the principles of data transmission reinforced by laboratory exercises. Focuses on the three lowest layers: media, physical, and data link layers.

ICS 4382. Data Communication Performance
2-6-4. Prerequisite: ICS 4381.
A detailed examination of the performance of data transmission systems. Emphasis will be placed on quantitative models of data link control protocols and data communication equipment.

ICS 4390. Computer Graphics
3-0-3. Prerequisites: ICS 2201, MATH 2307.

Introductions to computer graphics: hardware, database, and software organizations for graphics; two-dimensional and three-dimensional transformations; fundamentals of vector and raster graphics; programming project implementing a subset of the above.

ICS 4410. Introduction to Compilers
3-0-3. Prerequisites: ICS 3410, 3602.

Study of the basic techniques of compiler design and implementation, with consideration of the implementation characteristics of widely used programming languages.

ICS 4430. Introduction to Operating Systems
3-0-3. Prerequisites: ICS 2101 (or equivalent), 3602.

A qualitative introduction to operating systems, including multiprogramming concepts, resource allocation and management, other functions performed, and operating system implementation.

ICS 4450. Introduction to Data Base Design
3-0-3. Prerequisites: ICS 2301, 3602.

Introduction to logical and physical structures of computer data base systems. Topics include data models, data base theory, query processing, usage of relational and network models of data bases.

ICS 4601. Computer Systems Laboratory I
1-6-3. Prerequisite: ICS 3602.

Hands-on hardware experiments for ICS majors. Construction and programming of an operating microcomputer.

ICS 4602. Computer Systems Laboratory II
1-6-3. Prerequisite: ICS 3602.

Intensive hands-on computer laboratory for ICS majors. Machine-level operations and programming. Modular synthesis of software functions.

ICS 4621. Introduction to Computer Architecture and Organization
3-0-3. Prerequisite: ICS 3602.

To describe the hardware design aspects of all major components of a computer system. The relevant aspects of software are also treated.

ICS 4651. Design Project I
0-3-1. Prerequisite: consent of the School.

First quarter of an undergraduate thesis sequence consisting of an analytic or empirical investigation in an approved area of information and computer science. Proposal preparation.

ICS 4652. Design Project II
0-3-1. Prerequisite: ICS 4651.

Second quarter of undergraduate thesis sequence. System analysis and design.

ICS 4653. Design Project III
0-12-4. Prerequisite: ICS 4652.

Third quarter of undergraduate thesis sequence. System implementation and final project report.

ICS 4753. Human Factors in Software Development
3-3-4. Prerequisites: ICS 1411, PSY 3304.

Examines human factors in the software design and application process from initial requirements to testing and implementation with emphasis on designing the user interface. Also listed as PSY 4753.

ICS 4754. Models of Human Information Processing
3-0-3. Prerequisites: PSY 3304, ICS 1700 or equivalent.

General and unified approaches to psychological and computer modeling of human information processes. Emphasis on neural, sensory, memory, semantic, and conceptual processing. Also listed as PSY 4754.

ICS 4801-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number. Prerequisite: consent of the School.

Courses of timely interest to the profession, conducted by resident or visiting faculty.

ICS 4901-2-3. Special Problems.
Credit to be arranged. Prerequisite: consent of the School.

Individual investigation of significant areas of information and computer science. Guided study and research.

ICS 6100. Foundations of Information Science
3-0-3.

Scientific method; subject of information science; sign processes; information and texts; measurement and information measures; laws and theories of information science; applications to information technology.

ICS 6130. Philosophy of Mind
3-0-3.

Higher mental processes, including learning, concept formation, problem solving and perception, considered in relation to artificial intelligence. Linguistic and physiological models of human information processes.

ICS 6135. Theory of Communication
3-0-3. Prerequisite: ICS 6130.

Man-machine communication is analyzed by reference to studies of behavioral decision, conversational systems, and interactive measurement methods.

ICS 6140. Systems Theory I
3-0-3.

Conceptional foundations of general systems theory; systems and the concept of state; systems dynamics; linear systems; controllability, reachability, and observability; stability, algebraic approaches to realization.

ICS 6144-5. Information Systems Design I, II
3-0-3 each.

Analysis and synthesis of information systems. Study of selected systems in areas such as data processing, management, command and control systems.

ICS 6152. Theory of Automata
3-0-3. Prerequisite: ICS 4155.

Study of the significant results concerning finite automata, pushdown automata, linear-bounded automata. Turing machines, recognizers of the four Chomsky phrase-structure languages.

ICS 6153. Theory of Compiling and Translation
3-0-3. Prerequisites: ICS 3155 or 6152, 4410.

A survey of theoretical topics related to compiler design and implementation: deterministic parsing, table processing, code generation, syntax-directed compiling, global optimization.

ICS 6155. Analysis of Algorithms
3-0-3. Prerequisite: ICS 4155.

Basic techniques for analyzing and designing efficient algorithms: upper and lower time-space bounds for data structure, sorting and combinatorial problems, algebraic algorithms.

ICS 6156. Complexity of Computation
3-0-3. Prerequisite: ICS 6155.

Advanced techniques for analyzing the time-space complexity of natural computational problems; proving the tractability or intractability of problems from algebra, combinatorics, computer science, geometry, and number theory.

ICS 6157. Advanced Theory of Computability
3-0-3. Prerequisite: ICS 4155.

Advanced treatment of the theory of computability. Topics include recursive functions, recursively enumerable sets and relations, degrees of unsolvability, the recursion theorem and computational complexity.

ICS 6240. Organization and Management of Information Industry
3-0-3.

Organization, operation, and management of the information industry. Information economics. Software companies. Information brokers. Vendor relationships. Issues of ethics, privacy, security, and auditing.

ICS 6342. Knowledge Structures for Machine Intelligence
3-0-3. Prerequisite: ICS 4344.

A study of the knowledge and inferences necessary for understanding and problem solving; memory organization; representation of episodes; question answering; reconstructive memory.

ICS 6347. Computer-aided Modeling
3-0-3. Prerequisites: MATH 3215, ICS 2602.

Modeling of complex systems especially for digital simulation. Statistical and other methodological considerations. Simulation versus mathematical, numerical, and other analysis. Projects in modeling and simulations.

ICS 6361. Artificial Intelligence
3-6-5. Prerequisite: ICS 3361 or graduate standing.

Advanced study of topics from problem solving, knowledge representation, expert systems, natural language processing, learning, and other current areas.

ICS 6363. Pattern Recognition
3-0-3. Prerequisite: MATH 3215 or equivalent.

Basic principles and methods of statistical pattern recognition; decision functions; pattern classifications by distance and likelihood functions; trainable pattern classifiers; feature extraction.

ICS 6370. Information Control Methods
3-0-3.

Study of methods of information control. Includes assessment of information needs, data collection and reduction, manual and automatic indexing, abstracting and classification, evaluation and performance.

ICS 6380. Computer Networks
3-0-3. Prerequisites: ICS 4380, 4430.

In-depth examination of the design and operation of computer networks covering computer hardware and software functions and design requirements and communication subsystems.

ICS 6410. Computer Language Design
3-0-3. Prerequisite: ICS 3410 or 4410.

Description, structure, and design philosophies of high-level programming languages. Design aspects of names and types, data and control structures, and features for data abstraction and modularity.

ICS 6415. Compiler Construction
3-3-4. Prerequisite: ICS 4410.

Detailed study of compiler implementation techniques, with an emphasis on the design and use of tools that partially automate compiler construction.

ICS 6420. Computer Operating Systems
3-3-4. Prerequisite: ICS 4430.

A coverage of operating system architecture, functions, and implementaion details. Involves concurrent processing, scheduling, storage, and device management. Also covers aspects of distributed system architecture. Includes a major implementation project.

ICS 6431. Design of Computer Operating Systems
1-6-3. Prerequisite: ICS 6420.

A major systems programming project involving the modification or extension of an existing operating system component and an evaluation of the results.

ICS 6436. Computer Systems Evaluation
3-3-4. Prerequisites: ICS 4380, 4430, MATH 3215.

Methods of evaluating performance of large-scale computer systems, with emphasis on performance analysis through simulation, queueing models, and measurement.

ICS 6450. Data Base Design
2-3-3. Prerequisites: ICS 4155, 4450.

Study of the state of the art of data base design. Approaches to data base theory and optimization of data base algorithms. Term project.

ICS 6530. Graph Theory
3-0-3. Prerequisite: MATH 3012.

Graph structure and algorithms, including trees, circuits, planarity, enumeration, combinatorics, network flows, and algorithm complexity, with applications in information and computer science.

ICS 6555. Queueing Theory and Applications I
3-0-3. Prerequisites: MATH 3215, ICS 4430.

Queueing theory and its application in computer performance evaluation, operating systems design, telecommunications, and operations research.

ICS 6556. Queueing Theory and Applications II
3-0-3. Prerequisite: ICS 6555.

Continuation of ICS 6555, emphasizing current research topics. Problems suitable for dissertation research are discussed.

ICS 6600. Advanced Small-scale Computer Systems
1-6-3. Prerequisite: ICS 3602.

The design and application of software and hardware for actual computer systems is introduced through hands-on laboratory experience with hardware modules, microcomputers, and interface subsystems.

ICS 6620. Advanced Computer Organization
3-0-3. Prerequisite: ICS 4621.

Studies of computer system organizations: advanced input output systems, multiprocessors, pipeline processors, other parallel systems.

ICS 6751. Human-Computer Interface
3-3-4.
Human-computer interface is considered in terms of user-system compatibility. Concepts in human factors and interface design are covered in relation to capabilities of both humans and computers. Also listed as PSY 6751.

ICS 6790. Computer Integrated Manufacturing Systems I
3-0-3. Prerequisite: graduate standing (priority to CIMS students).
A broad overview of the functions, processes, and disciplines of computer integrated manufacturing.

ICS 6791. Computer Integrated Manufacturing Systems II
3-0-3. Prerequisite: ICS 6790.
An in-depth study of current issues, emerging technologies, and future developments in computer integrated manufacturing.

ICS 6792. Computer Integrated Manufacturing Systems Seminar
1-0-1. Prerequisite: graduate standing.
Guest speakers on a broad range of CIMS-related topics: research, applications, and technology.

ICS 7000. Master's Thesis
Credit to be arranged. Prerequisite: consent of the School.

ICS 7999. Preparation for Doctoral Qualifying Exams
Credit to be arranged. Prerequisite: consent of the School.

ICS 8111-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number. Prerequisite: consent of the School.
Special topics of current interest. Treatment of new developments in various areas of information and computer science.

ICS 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of the School.
Small-group or individual investigation of advanced topics in information and computer science. Guided study and research. Maximum of five credit hours allowed toward the ICS M.S. degree.

ICS 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

ICS 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

ICS 8999. Doctoral Thesis Preparation
Credit to be arranged. Audit only. Prerequisite: consent of the School.

ICS 9000. Doctoral Thesis
Credit to be arranged. Prerequisite: consent of the School.

School of Mathematics
Established in 1952

Director and Regents' Professor—William F. Ames; *Assistant Director and Associate Professor*—Dar-Veig Ho; *Coordinator of Graduate Programs and Professor*—James V. Herod; *Coordinator of Undergraduate Programs and Associate Professor*—William L. Green; *Computer Coordinator and Professor*—William J. Kammerer; *Professors*—Michael F. Barnsley, Johan G. Belinfante, George L. Cain, Jr., Bertram M. Drucker (emeritus), Richard A. Duke, Jamie J. Goode, Les A. Karlovitz, Robert H. Kasriel (emeritus), Gunter H. Meyer, John D. Neff, Daniel A. Robinson, Michael P. Stallybrass, Yung L. Tong, James W. Walker (emeritus); *Associate Professors*—Alfred D. Andrew, Nathaniel Chafee, Stephen G. Demko, Donald M. Friedlen, Jeffrey Geronimo, Evans Harrell, Theodore P. Hill, Roger D. Johnson, Robert P. Kertz, William J. Layton, John P. Line, Thomas D. Morley, James M. Osborn, Kevin T. Phelps, E. Juanita Pitts, Ronald W. Shenk, Alan D. Sloan, William R. Smythe, Jr., Jonathan E. Spingarn, M. Carl Spruill, Frank W. Stallard (emeritus), Ernst Stephan; *Assistant Professors*—John H. Elton, Joel C. Fowler, Esther R. Lamken.

General Information
Mathematics forms an integral part of the curricula of most students at Georgia Tech. Consequently, the School of Mathematics offers a wide range of courses serving students in the various engineering, science, and management disciplines. In addition, the School offers programs of study leading to the bachelor's, master's, and doctoral degrees in mathematics. Such programs of study serve as preparation for mathematics careers, professional schools, and graduate studies.

In addition to basic courses in mathematics, the School offers a variety of specialized courses at the undergraduate and graduate levels, emphasizing areas related to the research activities of the faculty. At present, these include mathematical analysis, applied mathematics, differential equations, scientific computing, probability, statistics, combinatorics, mathematical physics, topology, and algebra.

The School of Mathematics has excellent computer facilities that are used in conjunction with an increasing number of courses and programs of study.

A cooperative plan for students who wish to combine practical experience with academic work is now available for mathematics majors.

Information supplementary to this catalog that may be useful to students planning or considering a program of study in mathematics is available in the School office. In particular, the School maintains a list of suggested undergraduate tracks that can be included in the programs of any interested student.

Undergraduate Program
Reflecting the scientific environment at Georgia Tech, the bachelor's program in mathematics trains students in the traditional core mathematics curriculum, as well as in its applications. The undergraduate program is sufficiently flexible to accommodate the wide variety of interests of undergraduate majors, and yet by its scientific breadth, it prepares the student for the extensive employment opportunities that exist for applied mathematicians.

Students are encouraged to develop an expertise in another field related to mathematics. This can be accomplished by developing a program of study involving technical electives and an appropriate concentration within mathematics. Some of the more popular fields include physics, computer science, electrical engineering, industrial engineering, operations research, and management. Concentrations within mathematics include scientific computing, engineering mathematics, mathematical physics, probability/statistics, and optimization. In addition, the School of Mathematics has a large computer lab and utilizes micro- and mini-computers throughout the undergraduate curriculum.

Students may count no more than six hours of course work in physical education toward graduation. Only free electives in the degree program may be taken on a pass/fail basis, and no more than twelve hours are allowed under this option.

In addition to the institutional requirement of at least a 2.0 grade point average for the entire academic program, the School of Mathematics requires a grade of C or better in each of MATH 4101, 4301, 4311, 4312, and 4320.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
English Elective	.....	.....	3-0-3
CHEM 1101-2 or 1111-2 General Chemistry	4-3-5	4-3-5	.....
PHYS 2121 Particle Dynamics	.....	.....	4-3-5
ICS 1410-1 Programming Concepts, Standards, and Methods I, II	.....	3-3-4	3-3-4
Physical Education (requirements, p. 253)	X-X-3	.....	.....
TOTALS	X-X-16	16-6-17	16-6-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
MATH 3308 Differential Equations	.....	.....	5-0-5
MATH 3215 Probability and Statistics	.....	.....	5-0-5
PHYS 2122-3 Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	.....
Social Sciences or Humanities Electives	3-0-3	3-0-3	3-0-3
Free Electives	3-0-3	3-0-3	3-0-3
TOTALS	15-3-16	15-3-16	16-0-16

Junior and Senior Years

Course	Credit Hours
MATH 4101, 4301, 4311, 4312, 4320	19

PHYS 3121 5
Course work at or above the 3000
level in one degree-granting school
other than mathematics 9
Mathematics courses at or above the 4000 level 24
Humanities and social sciences courses (the
degree program must include either a year
sequence in a modern language, or nine
additional hours of English) 18
Free electives 14

TOTAL   89

SUBSTITUTIONS
PHYS 2141-2-3 may be substituted for
2121-2-3 respectively. Certain blanket sub-
stitutions are allowed for ICS 1410-11.
Information about these substitutions may be
obtained from the School.

ELECTIVES
English Elective
Any English course that carries humanities
credit.

Humanities and Social Sciences Electives
The Institute requires eighteen hours in the
humanities and eighteen hours in the social
sciences. See "Information for Undergradu-
ates," pp. 41-42.
The School of Mathematics recommends
a one-year sequence of courses in a modern
language. It also recommends that each
student begin the sequence of required 4000-
level mathematics courses in his/her junior
year. All students are required to pass
examinations or courses in the history and
constitutions of the United States and
Georgia. HIST 1001 or 1002 and POL 1251
or 3200 fulfill this requirement.

Graduate Programs
The School of Mathematics provides oppor-
tunities for study in a wide range of
mathematical disciplines. First-year graduate
sequences include algebra, analysis, dif-
ferential equations, numerical analysis,
probability, statistics, and topology in addi-
tion to courses in methods of applied
mathematics.
A program of study leading toward a
master's degree should include analysis con-
sisting of MATH 6317, 6318, 6320, and
6580. In addition, students should take six
hours of course work at the 3000 level or

higher outside of the School of Mathematics.
The program should also include either a
thesis (seventeen hours) and seven additional
hours of course work at the 4000 level or
higher or twenty-nine hours of course work
at the 4000 level or higher, including nine
hours of concentration in some field of
mathematics, three hours in numerical analy-
sis, and three hours in probability, statistics,
or stochastic processes (unless the student
has previously had such training) and a
sufficient number of hours at the 6000 level
or higher to ensure that the program includes
a total of at least thirty-five hours at this
level. The courses MATH 4101, 4301, 4311,
4312, 4313 and 4320 do not carry graduate
credit for mathematics students and may not
be used to satisfy these requirements.
Students must maintain an overall grade
point average of at least 2.7 and receive a
grade of C or better in each mathematics
course in the program of study.
Before admission to candidacy for the
master's degree, each student must pass an
oral comprehensive examination. Most
applicants holding the bachelor's degree are
urged to enter the master's degree program
before seeking admission to the doctoral
program.
Students with the master's degree or
equivalent may apply for the doctoral pro-
gram. This program requires seventy-seven
hours of course work beyond the under-
graduate degree, with at least five hours in
real, functional, complex analysis, algebra,
topology, and mathematical modeling. Fif-
teen of these hours must be taken outside the
School of Mathematics in the student's
minor field of study. Students must maintain
an overall grade point average of 2.7 and a
grade of C or better in each course of the
program of study.
Prior to admission to candidacy for the
doctoral degree, each student must pass
comprehensive examinations in each of four
areas of mathematics selected in part by the
student. Also, doctoral candidates must dem-
onstrate a reading knowledge of one lan-
guage chosen from French, German, and
Russian and satisfy the Institute requirements
with respect to the dissertation and final oral
examination.

Program in Statistics
For information concerning the graduate
program in statistics, refer to page 132.

Courses of Instruction
MATH 1301. Introduction to Mathematical Sciences
1-0-1. Prerequisite: none.
Elementary lectures in various areas of modern
mathematics by the faculty of the School.
Text: at the level of Eves, *Great Moments in
Mathematics*.

MATH 1302. Computers in Mathematics
0-2-1. Prerequisites: MATH 1308 or 1318 and knowledge
of a programming language.
Introduction to microcomputers and their application in
the calculus. Use of School Microcomputer Lab.
Text: none.

MATH 1307. Calculus I
5-0-5. Prerequisite: admission requirements in mathe-
matics or MATH 1709. Concurrent registration with
MATH 1308 is not permitted.
The derivative, derivatives of elementary functions,
applications of derivatives. Credit is not allowed for both
MATH 1307 and MATH 1712.
Text: at the level of Thomas and Finney, *Calculus and
Analytic Geometry*.

MATH 1308. Calculus II
5-0-5. Prerequisite: MATH 1307. Concurrent registration
with MATH 1307 or MATH 1309 is not permitted.
Integral calculus, notion of integral, definite and
indefinite integrals, techniques of integration, applications,
approximate methods, improper integrals. Credit is not
allowed for both MATH 1308 and MATH 1713.
Text: at the level of Thomas and Finney, *Calculus and
Analytic Geometry*.

MATH 1309. Calculus III
5-0-5. Prerequisite: MATH 1308. Concurrent registration
with MATH 1308 or MATH 2307 is not permitted.
Complex numbers; first and second order differential
equations; applications in oscillations; geometry in E;
vectors, matrices, systems of linear algebraic equations.
Text: at the level of Thomas and Finney, *Calculus and
Analytic Geometry*.

MATH 1317-8-9. Honors Calculus I, II, III
5-0-5 each.
The topics covered parallel those of MATH 1307-8-9,
with a treatment somewhat more intensive and rigorous.
Credit is not allowed for both an honors calculus course
and the corresponding regular calculus course.

MATH 1409. Geometry for Architecture
5-0-5. Prerequisite: MATH 1307.
Development of spatial relationships through the study
of geometry; topics include trigonometry, conic sections,
projective geometry, solar calculations, tiltings of the
plane, and polyhedra.
Text: lecture notes.

**MATH 1708. Precalculus Mathematics for
Management**
5-0-5. Prerequisite: none.

Analytic geometry, function, concept, polynomials,
exponentials, logarithms, linear equations, mathematical
induction.
Text: at the level of Crabtree, *Precalculus*.

MATH 1709. Precalculus for Science and Engineering
5-0-5.
Analytic geometry, the function concept, exponentials,
logarithmic and trigonometric functions, theory of equa-
tions including trigonometric equations.
Text: at the level of Crabtree, *Precalculus*.

MATH 1711. Mathematics for Management I
5-0-5. Prerequisite: passing of an entrance test or MATH
1708.
Linear equations and straight lines, matrices, linear
programming, sets and counting, probability and statistics.
Text: at the level of Goldstein, Lay, and Schneider,
Modern Mathematics and Its Applications.

MATH 1712. Mathematics for Management II
5-0-5. Prerequisite: MATH 1711.
Difference equations and the mathematics of finance,
functions, the derivative, applications of the derivative,
techniques of differentiation. Credit is not allowed for
both MATH 1712 and 1307.
Text: at the level of Goldstein, Lay, and Schneider,
Modern Mathematics and Its Applications.

MATH 1713. Mathematics for Management III
5-0-5. Prerequisite: MATH 1712 or 1307.
The exponential and natural logarithm functions with
applications to exponential growth and decay and com-
pound interest, integration, functions of several variables
including partial derivatives, maxima and minima of
functions of several variables. Lagrange multipliers and
constrained optimization. Credit is not allowed for both
MATH 1713 and MATH 1308.
Text: at the level of Goldstein, Lay, and Schneider,
Modern Mathematics and Its Applications.

MATH 2012. Boolean Algebra and Applications
3-0-3. Prerequisite: MATH 1307 or 1711.
Introduction to discrete algebraic structures such as
partial orders, lattices, and Boolean algebras, including
the algebra of sets and propositional logic with applica-
tions to circuits.
Text: at the level of Mendelson, *Boolean Algebra and
Switching Circuits*.

MATH 2307. Calculus IV
5-0-5. Prerequisite: MATH 1309. Concurrent registration
with MATH 1309 or MATH 2308 is not permitted.
Linear algebra, linear independence, bases, eigenvalues
and eigenvectors, partial derivatives, differentiable func-
tions, gradient, maximum and minimum problems.
Text: at the level of Grossman, *Calculus Part Two*.

MATH 2308. Calculus V
5-0-5. Prerequisite: MATH 2307. Concurrent registration
with MATH 2307 or 2309 is not permitted.
Multiple integration, line and surface integrals, integral
theorems and applications; infinite series, Taylor's
theorem.
Text: at the level of Thomas and Finney, *Calculus and
Analytic Geometry*.

MATH 2309. Differential Equations
5-0-5. Prerequisite: MATH 2308.
Linear and elementary nonlinear differential equations and physical applications, systems of differential equations, series solutions. Numerical methods emphasized.
Text: at the level of Sanchez, *Differential Equations*.

MATH 2317-8. Honors Calculus IV, V
5-0-5 each.
A continuation of MATH 1317, 1318, 1319. The coverage parallels that of MATH 2307-8.

MATH 2801-2-3-4-5. Special Topics
1-0-1 through 5-0-5 (respectively).
Courses on special topics of current interest in mathematics.

MATH 3012. Applied Combinatorics
3-0-3. Prerequisite: MATH 1308 or 1712.
Elementary combinatorial techniques used in discrete problem solving. Topics include basic counting methods, graph and network models, related algorithms for searching and selecting.
Text: at the level of Berman and Fryer, *Introduction to Combinatorics*.

MATH 3110. Introduction to Higher Algebra
3-0-3. Prerequisite: MATH 2307 or 1713.
Vector spaces, matrices, systems of linear equations, linear transformations and matrices, change of basis, characteristic roots and vectors, quadratic forms and diagonalization.
Text: at the level of Roberts, *Elementary Linear Algebra*.

MATH 3215. Problems in Probability and Statistics
5-0-5. Prerequisite: MATH 2308 or 1713.
Problem-oriented introduction to probability with applications (see MATH 4215) including models and problems in statistical inferences. Credit is not allowed for both MATH 3215 and 4215.
Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

MATH 3308. Differential Equations
5-0-5. Prerequisite: MATH 2308.
Differential equations with linear algebra, matrix treatment of linear systems, characteristic roots, exponential matrix function, series method stressing equations of Bessel and Legendre.
Text: at the level of Rabenstein, *Elementary Differential Equations with Linear Algebra*.

MATH 3640. Introduction to Scientific Computing
3-0-3. Prerequisites: MATH 2307 and knowledge of computer programming.
Solution of problems in economics, science, and technology employing algorithms for linear and nonlinear equations, integration and ordinary differential equations. Student use of computers emphasized.

MATH 3709. Mathematics for System Engineering
3-0-3. Prerequisite: MATH 2308.
Techniques for solving linear differential equations (and systems) with constant coefficients, e.g., with Laplace transform. Credit is not allowed for MATH 3709 and 2309 or 3308.
Text: at the level of Bronson, *Differential Equations*.

MATH 3710. Introduction to Statistics
5-0-5. Prerequisite: MATH 1308 or 1712.
Basic concepts and tools of statistical analysis as used in data analysis and inference in the behavioral, life, managerial, and physical sciences.
Text: at the level of Walpole, *Introduction to Statistics*.

MATH 3716. Statistics for Management Science
5-0-5. Prerequisites: MATH 2307 and MATH 3215.
Unified approach to statistical inferences through decision methods and to regression and experimental design through least squares. Topics are introduced with discipline-oriented problems.
Text: at the level of Walpole, *Introduction to Statistics*.

MATH 3801-2-3-4-5. Special Topics
1-0-1 through 5-0-5 (respectively).
Courses on special topics of current interest in mathematics.

MATH 4012. Discrete Algebraic Structures in Coding Theory
3-0-3. Prerequisites: MATH 2307, 3012, or 2012.
Algebraic and combinatorial structures, including finite fields, rings, finite geometries, designs, and codes are introduced. Use of these structures in constructing error-correcting codes is emphasized.

MATH 4101. Introduction to Abstract Algebra I
3-2-4. Prerequisite: MATH 2308.
An introduction to basic algebraic systems, with emphasis on groups, rings, and fields.
Text: at the level of Herstein, *Topics in Algebra*.

MATH 4102. Introduction to Abstract Algebra II
3-0-3. Prerequisite: MATH 4101.
A continuation of MATH 4101, with emphasis on modules, polynomial rings, and linear associative algebras.
Text: at the level of Herstein, *Topics in Algebra*.

MATH 4215. Introduction to Probability
3-0-3. Prerequisite: MATH 2308 or 1713.
Introduction to probability theory with applications, discrete and nondiscrete distributions, moments, laws of large numbers, central limit theorem with applications. Credit is not allowed for both MATH 4215 and 3215.
Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

MATH 4220. Elementary Discrete-Time Stochastic Processes
3-0-3. Prerequisite: MATH 3215 or 4215.
Development of random walk, waiting-time processes, and other stochastic processes through a problem-oriented approach. Methods of solution include counting techniques, recurrence relations, and generating functions.
Text: at the level of W. Feller, *An Introduction to Probability Theory and Its Applications*, vol. I.

MATH 4221. Probability with Applications I
3-0-3. Prerequisite: MATH 3215 or 4215.
Introduction to the Poisson process, renewal processes, and Markov chains.
Text: at the level of Ross, *Stochastic Processes*.

MATH 4222. Probability with Applications II
3-0-3. Prerequisite: MATH 4221.

Introduction to continuous-time Markov chains, Brownian motion, and martingales.
Text: at the level of Ross, *Stochastic Processes*.

MATH 4225. Computer Usage in Probability
3-0-3. Prerequisites: MATH 3215 or MATH 4215 and ICS 1700.
Study of probability distributions, limit laws, and applications through the use of digital computer. Probability (Monte Carlo) methods applied to deterministic problems.

MATH 4260. Introduction to Mathematical Statistics.
3-0-3. Prerequisites: MATH 2308 and either 3215 or 4215.
Unified approach to statistical estimation and testing of hypotheses, including introduction to Bayesian methods. Exact and asymptotic sampling distributions. Applications. No credit allowed for both MATH 4260 and 4262.
Text: at the level of Hel, Port and Stone, *Introduction to Statistical Theory*.

MATH 4262. Mathematical Statistics I.
3-0-3. Prerequisites: MATH 2308 and 3215 or equivalent.
Sampling distributions. Normal, t, chi-square, and F distributions. Bivariate and multivariate normal distributions. Limiting distributions of sample means and of order statistics. No credit allowed for both MATH 4262 and 4260.
Text: at the level of Hogg and Craig: *Introduction to Mathematical Statistics*.

MATH 4263. Mathematical Statistics II.
3-0-3. Prerequisite: MATH 4262
Point and interval estimation, Bayes estimates. UMP tests, likelihood ratio tests, goodness-of-fit tests and stochastic modeling. Analysis of variance and regression analysis.
Text: at the level of Hogg and Craig, *Introduction to Mathematical Statistics*.

MATH 4264. Mathematical Statistics III.
3-0-3. Prerequisite: MATH 4263
Nonparametric methods. Sufficiency and completeness. The exponential family and stochastic ordering. Introduction to sequential analysis and multiple comparisons.
Text: at the level of Hogg and Craig, *Introduction to Mathematical Statistics*.

MATH 4266. Nonparametric Statistics.
3-0-3. Prerequisite: MATH 4260 or equivalent.
Order statistics, goodness-of-fit tests, rank tests, tests of association, location tests, scale tests, asymptotic theory including use of Pitman efficiency.
Text: at the level of Gibbons, *Nonparametric Statistical Inference*.

MATH 4267. Multivariate Statistical Methods.
3-0-3. Prerequisites: MATH 3110 and 3215 or equivalent.
Multivariate normal and related distributions. Confidence regions and hypothesis testing for the mean vector. Discriminant analysis. Introduction to principle component analysis and cluster analysis.
Text: at the level of Morrison, *Multivariate Statistical Methods*.

MATH 4280. Elements of Information Theory
3-0-3. Prerequisite: MATH 3215 or 4215.

A mathematical approach to information theory, primarily through probability in finite sample spaces. Coding theorem for discrete memoryless channels. Decision schemes. Shannon's theorem.
Text: at the level of Ash, *Information Theory*.

MATH 4282. Introduction to Stochastic Processes
3-0-3. Prerequisite: MATH 3215 or 4215.
Second-order stochastic processes, especially stationary and weakly stationary processes. Gaussian processes. Spectral analysis.
Text: at the level of Yaglom, *Theory of Stationary Random Functions*.

MATH 4301. Finite-dimensional Vector Spaces
3-2-4. Prerequisite: MATH 2308.
A study of finite-dimensional vector spaces treating linear transformations, algebra of operators, inner product spaces, and normed linear spaces.
Text: at the level of Stoll and Wong, *Linear Algebra*.

MATH 4302. Applications of Finite-dimensional Vector Spaces
3-0-3. Prerequisite: MATH 4301.
Applications of MATH 4301, with topics selected from the areas of convex sets, positive matrices, quadratic forms, linear differential equations, and generalized inverses.

MATH 4311. Introduction to Analysis I
3-2-4. Prerequisite: MATH 2309 or 3308 or equivalent.
Real numbers, order completeness, normed vector spaces and notions of completeness and compactness, functions and continuity, sequences and series.
Text: at the level of Bartle, *The Element of Real Analysis*.

MATH 4312. Introduction to Analyis II
3-2-4. Prerequisite: MATH 4311.
Limits of functions, differentiation of functions of one variable, Riemann-Stieltjes integral, improper integrals, absolute and conditional convergence, integrals of sequences and series.
Text: at the level of Bartle, *The Elements of Real Analysis*.

MATH 4313. Introduction to Analysis III
3-2-4. Prerequisite: MATH 4312.
Differentiation in R, local inverse function theorem, implicit function theorem, extremum problems and Lagrange multipliers, integration of R, change of variables in multiple integrals.
Text: at the level of Bartle, *The Elements of Real Analysis*.

MATH 4320. Complex Analysis
3-0-3. Prerequisite: MATH 2309 or 3308.
Topics for complex function theory, including contour integration and conformal mapping.
Text: at the level of Churchill, *Complex Variables with Applications*.

MATH 4347. Introduction to Partial Differential Equations I
3-0-3. Prerequisite: MATH 2309 or 3308.
Method of characteristics for first- and second-order partial differential equations. Classification of second order equations. Applications.

MATH 4348. Introduction to Partial Differential Equations II
3-0-3. Prerequisite: MATH 2309 or 3308.
Solutions of boundary value problems for partial differential equations by Green's functions. Representative solutions for potential and diffusion equations. Applications.

MATH 4431. Introductory Topology
3-0-3. Prerequisite: MATH 4311 or consent of the School.
This course provides background for use of topological methods in analysis. Metric spaces. Continuous transformation. Topological spaces.
Text: at the level of Kasriel, *Undergraduate Topology.*

MATH 4432. Introduction to Algebraic Topology
3-0-3. Prerequisites: MATH 4431 and 4101 or 4301.
Introduction to algebraic methods in topology. Includes homotopy, the fundamental group, covering spaces, simplicial complexes. Applications to fixed point theory and graph theory.
Text: at the level of Singer and Thorpe, *Elementary Topology and Geometry.*

MATH 4441. Differential Geometry
3-0-3. Prerequisite: MATH 2308.
The theory of curves and surfaces, including the first and second fundamental forms of a surface and topics related to them.
Text: at the level of O'Neil, *Elementary Differential Geometry.*

MATH 4580. Linear Programming
3-0-3. Prerequisite or corequisite: MATH 2308.
A study of the linear programming problem, including the simplex method, duality, and sensitivity analysis with applications to matrix games, integer programming, and networks.
Text: at the level of Chvatal, *Linear Programming.*

MATH 4581. Advanced Engineering Mathematics
3-0-3. Prerequisite: MATH 2309 or 3308.
The Laplace transform and its properties, applications to physical systems involving the solution of ordinary and partial differential equations.
Text: at the level of Churchill, *Operational Mathematics.*

MATH 4582. Advanced Engineering Mathematics
3-0-3. Prerequisite: MATH 2309 or 3308.
Fourier series, boundary value problems for partial differential equations, applications of Legendre polynomials and Bessel functions.
Text: at the level of Powers, *Boundary Value Problems.*

MATH 4583. Vector Analysis
3-0-3. Prerequisite: MATH 2308.
Vector calculus. Line, surface, and volume integrals. Gradient, divergence, curl. Theorems of Green, Gauss, and Stokes. Curvilinear coordinate systems. Introduction to tensors.
Text: at the level of Davis and Snider, *Introduction to Vector Analysis.*

MATH 4591. Introduction to Mathematical Optimization
3-0-3. Prerequisite: MATH 2308.
Introduction to various linear and nonlinear optimization problems in finite-dimensional spaces. Mathematical properties of the objective function will be examined and appropriate algorithms developed.
Text: at the level of Cooper and Steinberg, *Introduction to Methods of Optimization.*

MATH 4640. Scientific Computing I
3-0-3. Prerequisites: MATH 2308 and knowledge of computer programming.
Topics include finding zeros of functions, direct and iterative methods for solving linear systems of equations, polynomial interpolation and numerical integration, including Romberg and adaptive methods.

MATH 4641. Scientific Computing II
3-0-3. Prerequisite: MATH 4640 or consent of the School.
Topics covered include solution of ordinary differential equations, nonlinear systems of equations, eigenvalue problems, least squares and spline approximations.

MATH 4800. Special Topics
3-0-3. Prerequisite: consent of the School.
This course enables the School of Mathematics to comply with requests for courses in special topics. Given upon sufficient demand.

MATH 4801-2-3-4-5. Special Topics
1-0-1 through 5-0-5 (respectively).
Courses on special topics of current interest in Mathematics.

MATH 4999. Reading or Research
1 to 3 credits. Prerequisites: junior standing or above, consent of the School.
Pass/fail basis only. Not more than seven hours can be counted toward bachelor's degree. At most, three hours can be counted as mathematics elective.

MATH 6012. Combinatorial Methods
3-0-3. Prerequisite: graduate standing or consent of the School.
Introduction to fundamental methods in graph theory, enumeration, and designs, including the use of recurrence relations, generating functions, trees, circuits, matchings, and graph colorings.

MATH 6121. Modern Abstract Algebra I
3-0-3. Prerequisites: MATH 4101, 4301.
An introduction to algebraic systems with emphasis on group theory.
Text: at the level of Lang, *Algebra.*

MATH 6122. Modern Abstract Algebra II
3-0-3. Prerequisite: MATH 6121.
Rings, ideals, and related concepts, field theory unique factorization.
Text: at the level of Lang, *Algebra.*

MATH 6123. Modern Abstract Algebra III
3-0-3. Prerequisite: MATH 6122.
Concept of the total matrix algebra. Introduction to linear associative algebras.
Text: at the level of Lang, *Algebra.*

MATH 6241-2-3. Probability I, II, III
3-0-3 each. Prerequisite: MATH 6317 or equivalent.
This sequence develops the probability basis requisite in modern statistical theories and stochastic processes. It includes a selection of topics from measure and integration theory, distribution functions, convergence concepts, Fourier integrals and central limit theory, conditional distributions and dependence and random analysis.

MATH 6261. Mathematical Statistics
3-0-3. Prerequisite: MATH 4241.
Detailed nonmeasure-theoretic treatment of minimum variance unbiased estimation and hypothesis testing, including UMP, UMP unbiased, best invariant, and locally best tests.
Text: at the level of Ferguson, *Mathematical Statistics.*

MATH 6262. Advanced Statistical Inference I.
3-0-3. Prerequisite: MATH 4264.
Statistical decision theory, admissibility, completeness and Bayes rules, minimax rules. The separating hyperplane theorem and the complete class theorem. Exponential families and complete sufficient statistics.
Text: At the level of Ferguson, *Mathematical Statistics: A Decision Theoretic Approach.*

MATH 6263. Advanced Statistical Inference II.
3-0-3. Prerequisite: MATH 6262.
Invariant statistical decision problems, admissible and minimax invariant rules. Location and scale parameters. Lehmann-Scheffe Theorem and Rao-Blackwell Theorem, uniformly minimum variance unbiased estimators.
Text: at the level of Ferguson, *Mathematical Statistics: A Decision Theoretic Approach.*

MATH 6264. Advanced Statistical Inference III.
3-0-3. Prerequisite: MATH 6263.
The Neyman-Pearson Lemma, UMP tests, and UMP unbiased tests. Invariance in hypothesis testing. The general linear hypothesis and multiple comparisons. Multiple decision theory.
Text: at the level of Ferguson, *Mathematical Statistics: A Decision Theoretic Approach.*

MATH 6266. Linear Models.
3-0-3. Prerequisite: MATH 4262 or 4260.
Unified approach to regression analysis, analysis of variance and experimental design, making use of linear algebra and generalized inverses. Applications.
Text: at the level of Graybill, *Theory and Application of the Linear Model.*

MATH 6307-8-9. Ordinary Differential Equations I, II, III
3-0-3 each. Prerequisites: MATH 3110, 4313.
This sequence develops the qualitative theory for systems of ordinary differential equations. Initial-value problems for systems and nth order equations. Differential inequalities. Stability of linear and perturbed linear systems, Liapunov functions. Boundary-value problems. Periodic solutions and behavior near periodic orbits. Oscillation and comparison theorems. Asymptotic behavior.

MATH 6315. Real Analysis II
3-0-3. Prerequisite: MATH 6317.

Topics such as structure of the real numbers, axiom of choice, Zorn's Lemma. Hamel basis, Baire category theorem, Stone-Weierstrass theorem, and the Daniell integral.

MATH 6317. Analysis I
4-0-4. Prerequisite: MATH 4313 or consent of the School.
Lebesgue measure, measurable functions, Lebesgue integration, convergence theorems for integrable functions, signed measures, Hahn decomposition theorem, absolute continuity and differentiation, Radon-Nikodym theorem, Fubini's theorem.

MATH 6318. Analysis II
3-0-3. Prerequisite: MATH 6317 or consent of the School.
L-spaces, metric spaces, normed linear spaces, linear operators, Hahn-Banach theorem, open mapping theorem, strong and weak convergence.

MATH 6320. Complex Analysis I
5-0-5. Prerequisites: MATH 4311, 4312, 4313, 4320.
Analytic functions, harmonic functions, conformal mapping, Cauchy's theorem, Cauchy's formulas for derivatives, maximum principle, power series, argument principle, residue theory, contour integration, analytic continuation, applications.

MATH 6325. Complex Analysis II
3-0-3. Prerequisite: MATH 6320.
Analytic continuation, product and partial fraction representation of meromorphic functions, Mittag-Leffler theorem, conformal mapping, Schwarz-Christoffel transformations, application to Dirichlet's Problem, normal families, Riemann mapping theorem.

MATH 6335. Functional Analysis II
3-0-3. Prerequisite: MATH 6318.
Elements of nonlinear functional analysis, fixed point theorems; locally convex linear topological spaces, Krein Milman theorem, spectral decomposition theorems, Banach algebras.

MATH 6341. Partial Differential Equations I
3-0-3. Prerequisites: MATH 4311, 4312, 4313, 4582.
Classification of partial differential equations, canonical forms, well posed problems, wave equation in R, Huyen's principle, potential equation, heat equation, strong maximum principles, fundamental solutions.

MATH 6342. Partial Differential Equations II
3-0-3. Prerequisite: MATH 6341.
Existence theory for elliptic equations, single and double layer potentials, Schwarz alternating procedure, subharmonic functions, weak solutions in a Sobolev space, regularity of weak solutions.

MATH 6343. Partial Differential Equations III
3-0-3. Prerequisite: MATH 6342.
Finite dimensional approximation of weak solutions, existence theory for evolution equations, semigroups, fundamental solutions, regularity of solutions, nonlinear evolution equations.

MATH 6431-2-3. General Topology I, II, III
3-0-3 each. Prerequisite: MATH 4431 or consent of the School.
Bases and subbases, filters, nets and convergence, continuous functions, separation axioms, connectedness, separability, compactness, sup and weak topologies,

products and quotients, compactifications and other embeddings, completeness and Baire category, uniform spaces, metrization, function spaces, topological groups.
Text: at the level of Wilansky, *Topology for Analysis*.

MATH 6441-2-3. Algebraic Topology I, II, III
3-0-3. Prerequisites: MATH 4431, 4101, and 4301 or consent of the School.
Introduction to homological algebra, Cech and singular homology and cohomology theories. Applications to fixed points of maps, spheres, invariance of domain, etc., homotopy, the fundamental group, covering spaces. Introduction to sheaf theory, category theory, spectral sequences.
Text: at the level of Spanier, *Algebraic Topology*.

MATH 6501. Methods of Applied Mathematics I
3-0-3. Prerequisite: MATH 2309 or 3308, and 3110 or consent of the School.
The first of five courses providing access to mathematical methods important in science and engineering. Complex analysis. Credit not allowed toward graduate degrees in mathematics.
Text: none.

MATH 6502. Methods of Applied Mathematics II
3-0-3. Prerequisite: MATH 6501.
A continuation of MATH 6501. Partial differential equations and special functions. Credit not allowed toward graduate degrees in mathematics.
Text: none.

MATH 6510. Deterministic Models from the Physical Sciences and Technology
5-0-5. Prerequisites: PHYS 3121, MATH 4582.
Electrical, mechanical, thermal systems leading to difference equations. Lumped parameter electrical, mechanical systems leading to ordinary differential equations. Distributed-parameter systems leading to partial diferential equations.

MATH 6580. Introduction to Hilbert Spaces
3-0-3. Prerequisite: MATH 4301 or consent of the School.
Vector spaces, function spaces, inner products, projections, least squares, Fourier series, integral and differential operators, self-adjoint operators, compact operators, eigenvalues, eigenfunctions, contraction mappings.

MATH 6581. Calculus of Variations
3-0-3. Prerequisite: MATH 2309 or 3308 or consent of the School.
Constrained and unconstrained problems involving single and multiple integrals and added terms. Natural boundary conditions. Transitivity. Broken extremals. Hamilton's principle.

MATH 6582. Integral Transforms
3-0-3. Prerequisites: MATH 4582 and 4320 or consent of the School.
Classical Fourier, Laplace, and Mellin transform theory with applications to boundary-value problems. Special attention to the judicious choice of transform. Successive use of transforms.

MATH 6583. Integral Equations
3-0-3. Prerequisite: MATH 2309 or 3308 or consent of the School.

Linear integral equations and their relation to differential equations. Hilbert-Schmidt theory. Eigenvalues. Applications.

MATH 6584. Special Functions of Higher Mathematics
3-0-3. Prerequisites: MATH 4320 or consent of the School.
The gamma function, Bessel functions, spherical harmonics, orthogonal polynomials, and other functions of particular interest in science and technology.

MATH 6586. Tensor Analysis
3-0-3. Prerequisites: MATH 3110 and 4583, or consent of the School.
Tensor algebra, covariant differentiation, Cartesian tensors, curvilinear coordinates, introduction to differential forms.
Text: at the level of Sokolnikoff, *Tensor Analysis*.

MATH 6640. Applied Computational Methods for Partial Differential Equations
3-0-3. Prerequisite: knowledge of computer programming, familiarity with partial differential equations and elements of scientific computation.
Algorithms using the finite differences and finite elements for the numerical solution of steady and transient problems of engineering and science. Student computer use emphasized.

MATH 6643. Numerical Linear Algebra
3-0-3. Prerequisite: MATH 4301 or consent of the School.
Numerical solutions of linear equations; least squares problems, the singular value decomposition and generalized inverse; methods for determining eigenvalues including the QR algorithm.

MATH 6644. Numerical Solution of Nonlinear Equations
3-0-3. Prerequisite: MATH 4311 or consent of the School.
Analysis of iterative methods for nonlinear finite and infinite dimensional equations, fixed point equations, Newton's method, gradient related methods, update methods, continuation methods.

MATH 6645. Numerical Approximation Theory
3-0-3. Prerequisite: MATH 4311 or consent of the School.
Theoretical and computational aspects of polynomial, rational and spline approximation, including Chebyshev and least squares approximation, linear methods of approximation, B-splines, mesh selection.

MATH 6646. Numerical Methods for Ordinary Differential Equations
3-0-3. Prerequisite: MATH 4311 or consent of the School.
Single and multistep methods for initial value problems, error and stability analysis, implicit methods for stiff problems, shooting methods for boundary value problems.

MATH 6647. Theory of Numerical Methods for Partial Differential Equations
3-0-3. Prerequisites: MATH 4313, 4347, 4301.
Finite difference and finite element approximations for elliptic and parabolic boundary value problems, error analysis for projection methods, characteristic methods for hyperbolic systems, stability analysis.

MATH 6750. Stochastic Models in Management Science
3-0-3. Prerequisites: MATH 4215, 2308.
Stochastic process models for managerial contexts including production, congestion, cash flow, fisheries, and passenger reservations. Processes include birth and death, renewal and Markov. Also listed as MSCI 6750.

MATH 7000. Master's Thesis

MATH 7999. Preparation for Doctoral Examinations
Credit to be arranged. Prerequisite: consent of the adviser.
Audit only.

MATH 8101-11-21-31-41-51. Special Topics
1-0-1. Prerequisite: consent of the School.
These courses enable the School of Mathematics to comply with requests for courses in selected topics.

MATH 8102-12-22-32-42-52. Special Topics
2-0-2.

MATH 8103-13-23-33-43-53. Special Topics
3-0-3.

MATH 8104-14-24-34-44-54. Special Topics
4-0-4.

MATH 8105-15-25-35-45-55. Special Topics
5-0-5.

MATH 8501-8599. Special Problems
Credit to be arranged. Prerequisite: consent of the adviser.

MATH 8997. Teaching Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

MATH 8998. Research Assistantship
Credit to be arranged. Audit basis only.
Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

MATH 9000. Doctoral Thesis.

Department of Military Science

Established in 1917

Professor and Head—Lieutenant Colonel Patrick Linhares; *Assistant Professors*— Majors James Elliott, Barringer F. Wingard, Napoleon Wright; Captain Timothy Miller, Captain Joseph Bost.

General Information
The purpose of the Army ROTC curriculum is to acquaint students with the Army, its role in our society, and the basic fundamentals of leadership and management. Concurrently, the overall program is designed to aid students in developing the abilities and attitudes that will make them

academically successful and to develop well-educated junior officers for the Active Army, the Army National Guard, and the Army Reserve.
The curriculum is divided into two courses: a Basic Course open to all freshmen and sophomores and an Advanced Course for qualified juniors, seniors, and graduate students. The student who is undecided about pursuing a commission has the option of participating in the Basic Course without incurring a military obligation. Successful completion of the Basic Course (or commensurate training), a minimum 2.0 cumulative grade point average, and the appropriate medical and physical qualifications are prerequisites for enrollment in the Advanced Course. Successful completion of both courses and the award of a bachelor's degree constitute the normal progression to gaining a commission as a Second Lieutenant. Courses are available to both men and women.
The overall Army ROTC curriculum prepares students to become effective leaders and managers in a variety of responsible and challenging commissioned officer fields, thus facilitating early middle management career development and progression. A description of the course requirements and associated programs is covered in the following paragraphs.

The Basic Course Curriculum
The basic program consists of a six-quarter block of instruction taken during the freshman and sophomore years. Successful completion of all six quarters satisfies the military science requirements for progression to the Advanced Course. These courses provide a foundation in basic military subjects such as customs and traditions, history, leadership, and map reading. They round out a student's academic life, provide a challenge, foster confidence, and facilitate personal growth and development. Courses are offered fall, winter, and spring quarters with two credit hours awarded for each course. Six hours of basic ROTC courses may be applied as elective credits toward degree requirements at the school. Courses normally meet two hours a week plus and

require a one-hour leadership laboratory. Students in the Basic Course do not incur any military obligation unless they are on an ROTC scholarship. They are issued uniforms and may participate in the other ROTC related events and training such as Airborne School, Air Assault School, and Northern Warfare Training. The Basic Course consists of the following:

Course	Credit Hours
MS 1021	
The Army of Today	2-1-2
MS 1022	
U.S. Military History	2-1-2
MS 1023	
Basic Military Navigation and Techniques	2-1-2
MS 2021	
Introduction to Leadership	2-1-2
MS 2012	
Analysis of Command and Leadership	2-1-2
MS 2023	
Military Training of the Individual	2-1-2
TOTAL	12-6-12

A total of six hours of basic ROTC courses may be applied toward a degree.

Optional Basic Camp

Those academically qualified students who are unable to fulfill the requirements of the Basic Program during their freshman and sophomore years may qualify for admission to the Advanced Course by successfully completing basic camp preparatory training. This option is primarily designed to meet the needs of transfer students, those completing the sophomore year, and others, including graduate students, who have six quarters remaining at the Institute. This option provides a two-year program in lieu of the standard four-year curriculum.

The basic camp option consists of a six-week training period conducted at an active Army post during the summer months. During each summer, various cycles will be available to meet student needs. Students choosing this option are required to submit a formal application and pass a general physical.

Students electing the basic camp training program will receive approximately $600 in addition to travel expenses to and from the camp. Uniforms, housing, medical care, and meals are furnished by the government during the camp. Interested students should contact the Military Science Department.

The Advanced Course Curriculum

The Advanced Course is designed to fully develop a cadet's leadership and management potential, physical stamina, and self-confidence, as well as those personal characteristics desired in an Army officer. The objective is to produce the highest caliber junior officer fully capable of discharging a wide spectrum of command and management responsibilities in the modern Army and in the business world.

The Advanced Course consists of six quarters of instruction normally taken during the junior and senior years. Successful completion of the six courses fulfills the military science academic requirements for award of an officer's commission. Eleven credit hours are earned, nine of which may be applied as elective credits toward any degree at the Institute. Advanced Course students receive a subsistence allowance of $100 a month, not to exceed $1,000 per academic year.

Service veterans, three- or four-year junior ROTC students, junior, or service academy cadets may qualify for direct entry into the Advanced Course. *Entry is not automatic,* and Department evaluation of previous training and academic achievement will determine appropriate placement level.

Advanced Course students are eligible to participate in the Simultaneous Membership Program with the Army Reserve and National Guard. Students in this program affiliate with an Army unit as an officer trainee, thus affording them the opportunity for enhanced leadership development. Students in this program receive an additional $90 per month.

Students enrolled in the Advanced Course are also required to complete a six-week advanced camp to become eligible for commissioning. Attendance at advanced camp normally occurs during the summer between the junior and senior years; however,

it may be delayed as in the case of students in the co-op program. Students can also participate in additional voluntary training, such as Airborne School, Ranger School, Cadet Flight Orientation Program, and Cadet Troop Leader Training. In addition to completing the military science academic requirements of both the Basic and Advanced Courses, the student must complete at least one undergraduate course from each of four designated fields of study:

Written Communications: select any course offered by the institution in English composition or creative writing.

Human Behavior: select any course offered by the institution in psychology, sociology, anthropology, or ethics.

Military History: select MS 1022 to meet requirement.

National Security Studies: select any course offered such as national defense/strategy, international relations, American foreign policy, or foreign policy of China or U.S.S.R.

ROTC scholarship students are also required to take a foreign language. They may choose any three-course one-year sequence offered by the Department of Modern Languages.

Students who successfully complete the Army ROTC curriculum and earn a bachelor's degree can be commissioned Second Lieutenants. Subsequent military service may be on active duty or with the Army Reserve or National Guard. Outstanding cadets who are selected as Distinguished Military students may gain Regular Army Commissions. The following courses constitute the Advanced Course:

Course	Credit Hours
MS 3011	
Advanced Military Navigation	2-1-2
MS 3012	
Tactical Decision Making I	2-1-2
MS 3023	
Tactical Decision Making II	2-1-2
MS 4011	
The Military Team and the Junior Officer	2-1-2
MS 4012	
Military Justice	2-1-2

MS 4023	
Professional Army Ethics	1-1-1
TOTAL	11-6-11

A total of nine credit hours of advanced ROTC courses may be applied toward a degree.

Scholarship Programs

Each year the Army offers a variety of full scholarship programs to those young men and women who have demonstrated outstanding academic scholarship and leadership potential. Four-year scholarships are awarded to incoming freshmen through national merit competition. Three-year and two-year scholarships are available on either a national competitive basis or directly through the professor of military science. Scholarships provide full tuition to both resident and out-of-state students, a stipend for textbooks and supplies, and laboratory fees in addition to a $100-a-month tax-free allowance. Scholarship students will serve either on active duty or in the reserves.

Options

Qualified students entering their junior year of college may request that they be guaranteed a particular branch of the Army; requirements vary.

Students who desire entry into the Army aviation program may apply for Flight Orientation in their junior year.

Those students who wish to obtain a commission as an officer but do not want to serve on active duty can request guaranteed reserve forces duty. In this program, students are guaranteed in writing that they will not be placed on active duty and can fulfill their entire commitment in the Army Reserve or National Guard.

The Department of Military Science allows both scholarship and nonscholarship students to participate in the co-op program. Co-op students are monitored and advised quarterly so that they meet requirements for commissioning.

Student Advisory Services

Faculty members are available throughout the academic year and during each summer

orientation session in the Department of Military Science for academic counseling, schedule planning, and career guidance. Students and their parents are encouraged to seek advice on the overall Army ROTC program, scholarship opportunities, and officer career development. Appointments may be made personally or by collect call to (404) 894-4760/4761.

Courses of Instruction

MS 1500. Ranger Company (Optional)
1-1-1. Audit only.
An organization designed to train and prepare the small-unit leader with patrolling, military mountaineering, and stream crossing operations in a demanding physical environment.

MS 1021. The Army of Today
2-1-2.
United States Army missions and organizations as related to national defense and national objectives; includes the role of the Army officer in today's dynamic environment.

MS 1022. United States Military History
2-1-2.
The origins of United States military tradition and the development of the military profession within today's total army.

MS 1023. Basic Military Navigation and Techniques
2-1-2.
Map reading and basic land navigation, with an introduction to individual military skills required as a member of a military organization.

MS 2012. Analysis of Command and Leadership
2-1-2.
Analysis and development of fundamental leadership skills required to lead individuals and small units in a military environment; includes use of case studies to develop organizational and leadership techniques. [Leadership Assessment Program (LAP)]

MS 2021. Introduction to Leadership
2-1-2.
Introduction to fundamental leadership and management dimensions. Student applies in a civilian environment the management dimensions of problem analysis and decision making; planning and organizing; delegation and control; and interpersonal communications.

MS 2023. Military Training of the Individual
2-1-2.
Introduction to military training management. Includes evaluating the training status of a unit, developing training objectives and standards, and planning and conducting military training.

MS 3011. Advanced Military Navigation
2-1-2. Prerequisite: Advanced Course standing or consent of the Department.

Military map reading, land navigation, and terrain analysis. Practical exercises require students to navigate cross country using terrain association and azimuths.

MS 3012. Tactical Decision Making I
2-1-2. Prerequisite: Advanced Course standing or consent of the Department.
Tactical decision-making process within small military units. Includes introduction to squad- and platoon-level tactics, with emphasis on troop leading procedures in a defensive setting.

MS 3023. Tactical Decision Making II
2-1-2. Prerequisite: Advanced Course standing or consent of the Department.
Continued study and application of the decision-making process at small-unit level. Emphasis is placed on planning and executing tactical operations in an offensive setting.

MS 4011. Military Team and the Junior Officer
2-1-2. Prerequisite: Advanced Course standing or consent of the Department.
A course organized to allow the potential officer to learn concepts and ease the transition from civilian to military officer.

MS 4012. Military Justice
2-1-2. Prerequisite: Advanced Course standing or consent of the Department.
This course is a study of military law, the Uniform Code of Military Justice, and the Law of War.

MS 4023. Professional Ethics and the Army Officer
1-1-1. Prerequisite: Advanced Course standing or consent of the Department.
A study of pressures and influences imposed by contemporary society on the military professional and the standards of conduct and special trust by which the military professional must function.

Department of Modern Languages
Established in 1904

Acting Department Head—Jerry Carroll Brooks; *Professor*—George F. Walker (adjunct), Louis J. Zahn; *Associate Professors*—William W. Johnson, Edmun B. Richmond, Heidi M. Rockwood; *Assistant Professors*—Barbara L. Blackbourn, Tatjana Gregory, Nicolas Hernandez, Jr., Maria S. Venable.

General Information
The diverse course offerings of the Department of Modern Languages provide students with opportunities for achieving reasonable fluency in understanding, speaking, reading, and writing several foreign languages (including English for nonnative speakers).

Further, they instruct students in the civilizations and literatures of the countries in which those languages are spoken.

Although the department does not offer a degree or "major," certificates or "minors" are available in French, German, linguistics, and Spanish. To receive a certificate in one of these options, students must take eighteen credit hours, fifteen hours of which must be on the 3000 level or above. Students should consult the Department for additional details.

Students may take any courses for which they have the prerequisites as specified in the catalog descriptions. Counseling and placement examinations are available on request. Usually two years in high school equal one year at Tech. Each course is essentially a unit in itself, but beginning students are encouraged to pursue at least the elementary three-quarter sequence in order to achieve a minimum level of proficiency. Students may not enroll in or receive advanced standing for 1000-level courses after the successful completion of any 2000-, 3000-, or 4000-level course. Students may, however, enroll simultaneously in a 1003 and a 2000-level course in the same language without special permission. Students who take courses in their native language must schedule courses no lower in number than 3001. Co-ops who are beginning a foreign language should limit themselves to French, German, and Spanish.

Courses at the 2000, 3000, and 4000 level do not have to be taken in chronological order, provided prerequisites are fulfilled.

With minor exceptions, students can fulfill their thirty-six-hour humanities and social sciences requirements for graduation by taking courses, including linguistics courses, in the Department of Modern Languages. Students should consult the catalog course descriptions and the section of this catalog titled "Humanities and Social Sciences Requirements," pp. 41-42, in order to determine which courses are classified as humanities and which are classified as social sciences in their respective colleges. With the approval of their major schools, students may take any courses offered by the Department of Modern Languages on a pass/fail basis.

Engineering College students who choose to begin the study of a foreign language (1001-2-3) must take in addition at least three three-hour courses at the 2000 level or higher if they wish to receive humanities credit for the 1000-level courses; otherwise those 1000-level courses will count as elective credit. Engineering College students should note that the aforementioned provision does not apply to linguistics; all linguistics courses on the 1000 and 2000 levels carry humanities credit both individually and collectively.

College Credit for High School Study
The Department will grant nine hours of elective credit in French, German, Italian, Portuguese, and Spanish or twelve hours in Russian for high school study in a foreign language, provided the student has two or more years of high school credit (or the equivalent) in the language in question and has completed nine quarter hours at the 2000, 3000, or 4000 level with an average grade of *C* or higher. Transfer students must complete at least three of the nine hours at Georgia Tech.

Students submitting a score of 4 or 5 on the College Entrance Examination Board Advanced Placement Examination in French, German, or Spanish "Language Level III" or "Literature Level III" may receive free elective credit for courses numbered 1001-2-3 in the respective language.

The Department will not grant credit for high school study in a foreign language to students who speak the language in question as their native language or to students who have taken 1000-level courses or the equivalent at Georgia Tech or at other college-level institutions for which they have received transfer credit.

To have this free elective credit entered on their records, students must request that the appropriate form be submitted by the Department of Modern Languages to the registrar. This elective credit is not applicable toward fulfillment of the thirty-six-hour social sciences and humanities requirements for graduation. No grade is attached to this credit.

Doctoral Degree Language Requirements
See page 51.

English for Foreign Students

All nonnative speakers of English must fulfill requirements in English for graduation either by taking the same courses required of native speakers, offered by the Department of English, or by taking the special series (FL 1031; FL 1032-33) offered by the Department of Modern Languages.

Nonnative speakers of English may take FL 1032-33 in lieu of the regular ENGL 1001-2 series with the following exceptions:

1) International students who have completed three years of study in an American high school and who have earned an American high school diploma must register for the regular ENGL 1001-2 series. These students must pass the Regents' Test.

2) Those international students who fail to meet the criteria for entrance into FL 1032 will be asked to first complete FL 0031.

The FL 1032-33 courses must be taken for a letter grade and must be taken in sequence.

Nonnative speakers of English who do not fit into category (1) above can fulfill the requirements of the Regents' Testing Program on competence in English by (1) passing the Regents' Test; (2) by completing the FL 1032-33 series and receiving a course grade of at least 80 in FL 1033, as well as receiving a grade of 85 or higher on the composition portion of the FL 1033 final examination; or (3) by taking the official *Michigan English Language Assessment Battery (MELAB)* and receiving an overall score of 80 or higher, with a grade of 85 or higher on the composition portion of the test.

Courses of Instruction

Note: (Hum.) = Humanities credit;
(Soc. Sci.) = Social Science credit.

Students in the College of Engineering may include up to nine hours (twelve hours in Russian) of elementary foreign language study for humanities credit, provided nine additional hours are completed on the 2000 or higher levels; otherwise the 1000-level course will count as elective credit. This regulation does not apply to courses in linguistics.

CHINESE

CHIN 1001. Introduction to Mandarin Chinese I
3-2-4. Prerequisite: one year college-level foreign language study or equivalent and consent of the Department.
Intensive study of patterns of expression in spoken Chinese.

CHIN 1002. Introduction to Mandarin Chinese II
3-2-4. Prerequisite: CHIN 1001 or equivalent.
Continuation of CHIN 1001; introduction to Chinese writing system.

CHIN 1003. Introduction to Mandarin Chinese III
3-2-4. Prerequisite: CHIN 1002 or equivalent.
Continuation of 1002; more emphasis on written Chinese.

CHIN 4901-2-3-4. Special Problems in Chinese
Credit to be arranged.
Provides the special instruction required under special programs.

FOREIGN LANGUAGE

FL 1011-12-13. Elementary Brazilian-Portuguese I, II, III
3-0-3 each course. Prerequisites: 1011—none; 1012—1011 or equivalent; 1013—1012 or equivalent.
Pronunciation, conversation, reading, composition, grammar. Audio-lingual methodology and materials. (Hum.)

FL 1021-22-23. Elementary Italian 1, II, III
3-0-3 each course. Prerequisites: 1021—none; 1022—1021 or equivalent; 1023—1022 or equivalent.
Pronunciation, conversation, reading, composition, grammar. Audio-lingual methodology and materials. (Hum.)

FL 0031. Remedial English as a Foreign Language I
5-0-5.
Special attention given to developing basic listening, vocabulary, and writing skills for nonnative speakers of English who need additional preparation for FL 1032-33. Cannot be counted for credit toward graduation.

FL 1032. English as a Foreign Language II
5-0-5. Prerequisite: FL 0031 or equivalent.
Stresses writing, reading, vocabulary. (Credit: 5 hours, Hum.)

FL 1033. English as a Foreign Language III
5-0-5. Prerequisite: FL 1032.
Stresses composition, readings on life in the United States. (Credit: 5 hours, Hum.)

FL 2011. Colonial Brazil and the Portuguese Empire, 1500-1808
3-0-3. Prerequisite: FL 1013 or equivalent.
Cultural history of Portuguese America from conquest and settlement to the end of the colonial period. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

FL 2012. Development of Independent Brazil, 1808-1930
3-0-3. Prerequisite: FL 1013 or equivalent.
Cultural history of Brazil from independence through the Empire and the Old Republic. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

FL 2013. Brazil since 1930: The Giant Emerges
3-0-3. Prerequisite: FL 1013 or equivalent.
Cultural history of contemporary Brazil from the rise of Vargas to the present day. Conducted in Portuguese. (Soc. Sci.)

FL 2021. Cultural History of Florence 1300 to 1500
3-0-3. Prerequisite: FL 1023 or equivalent.
Dante, Boccaccio, and the Medicis. Grammar review. Conducted in Italian. (Soc. Sci.)

FL 2022. Cultural History of Rome 1500 to 1700
3-0-3. Prerequisite: FL 1023 or equivalent.
Emphasis on Michelangelo, Bernini, Borromini. Grammar review. Conducted in Italian. (Soc. Sci.)

FL 2023. Cultural History of Italy since 1848
3-0-3. Prerequisite: FL 1023 or equivalent.
Unification, Fascism, resistance, postwar boom, current unrest. Conducted in Italian. (Soc. Sci.)

FL 3801-2-3-4. Special Topics in Modern Languages
3-0-3. Prerequisite: consent of head of the Department.
Permits students to do work in languages not treated in other courses and/or to engage in special research and/or experimental studies.

FRENCH

FREN 1001. Elementary French I
3-0-3.
Essential principles of French grammar and phonetics, acquisition of vocabulary through simple conversational exercises and the reading of simple selections. (Hum.)

FREN 1002. Elementary French II
3-0-3. Prerequisite: FREN 1001 or equivalent.
Continuation of FREN 1001, extension of the survey of French grammar, acquisition of a general vocabulary through conversation and reading. (Hum.)

FREN 1003. Elementary French III
3-0-3. Prerequisite: FREN 1002 or equivalent.
Reading of selected texts, composition, completion of the survey of French grammar. (Hum.)

FREN 2001. Cultural History of France to 1610
3-0-3. Prerequisite: FREN 1003, two years in high school, or equivalent.
Development and evolution of social structures of France as reflected in literature, history, and art. Includes a review of grammar. Conducted in French. (Soc. Sci.)

FREN 2002. Cultural History of France from 1610 to 1800
3-0-3. Prerequisite: FREN 1003, two years in high school, or equivalent.
Development and evolution of social structures of France from 1610 to 1800, as reflected in literature, history, and art. Continuation of a review of grammar. Conducted in French. (Soc. Sci.)

FREN 2003. Cultural History of France since 1800
3-0-3. Prerequisite: FREN 1003, two years in high school, or equivalent.
Development and evolution of social structures of France during the nineteenth and twentieth centuries as reflected in literature, history, and art. Concludes review of grammar. Conducted in French. (Soc. Sci.)

FREN 2021-2-3. Intermediate Conversation I, II, III
1-3-2 each. Prerequisite: FREN 1003, two years in high school, or equivalent.
A conversational approach to topics of current interest in the humanities in France. (Hum.)

FREN 3001. French Literature from 1800 to 1850
3-0-3. Prerequisite: FREN 2003 or equivalent.
Romanticism, the reappearance of lyric poetry, the importance of the individual as opposed to classical anonymity. Conducted in French. (Hum.)

FREN 3002. French Literature from 1850 to 1900
3-0-3. Prerequisite: FREN 2003 or equivalent.
Parnassianism and symbolism, developments in poetry, realism, and naturalism, trends in prose, with emphasis on the development of the novel. Conducted in French. (Hum.)

FREN 3003. French Literature since 1900
3-0-3. Prerequisite: FREN 2003 or equivalent.
Exploration of currents in modern prose, poetry, and drama. Conducted in French. (Hum.)

FREN 3004-5-6. Drama Workshop I, II, III
3-0-3 each. Prerequisite: FREN 2003 or equivalent. (Hum.)

FREN 3007-8-9. Survey of Literature I, II, III
3-0-3 each. Prerequisite: FREN 2003 or equivalent. (Hum.)

FREN 3011. France Today I
3-0-3. Prerequisite: FREN 2003 or equivalent.
Culture, history, and geography of modern France in lectures and class discussions, short papers on assigned topics; conducted in French. (Soc. Sci.)

FREN 3012. France Today II
3-0-3. Prerequisite: FREN 2003 or equivalent.
Continuation of FREN 3011. (Soc. Sci.)

FREN 3013. France Today III
3-0-3. Prerequisite: FREN 2003 or equivalent.
Continuation of FREN 3012. (Soc. Sci.)

FREN 3021-2-3. Advanced Conversation I, II, III
1-3-2 each. Prerequisite: 2003, 2023, or three years in high school or equivalent.
A conversational approach to topics of current interest in the social sciences in France. (Soc. Sci.)

FREN 4001. French Stylistics
3-0-3. Prerequisite: FREN 3003 or equivalent.
Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in French. (Hum.)

FREN 4002. Classical French Literature
3-0-3. Prerequisite: FREN 3003 or equivalent.
Survey of French classical literature, readings in Malherbe, Descartes, Pascal, La Rochefoucauld, La Fontaine, La Bruyere, Corneille, Moliere, and Racine. Lectures on the Classical Age; term report. Conducted in French. (Hum.)

FREN 4003. The French Novel
3-0-3. Prerequisite: FREN 3003 or equivalent.

Survey of the development of the French novel from the late seventeenth century through the twentieth century; term report. Conducted in French. (Hum.)

FREN 4901-2. Special Problems in French
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

GERMAN

GER 1001. Elementary German I
3-0-3.
Pronunciation, essential principles of German grammar, rapid acquisition of vocabulary by the reading of simple selections; elementary composition. (Hum.)

GER 1002. Elementary German II
3-0-3. Prerequisite: GER 1001 or equivalent.
Continuation of GER 1001. (Hum.)

GER 1003. Elementary German III
3-0-3. Prerequisite: GER 1002 or equivalent.
Reading and the acquisition of a large vocabulary; continued study of German grammar, composition. (Hum.)

GER 2001. Introduction to Modern German Culture I
3-0-3. Prerequisite: GER 1003 or equivalent.
Selected readings in German on the cultural, historical, and intellectual development of Germany. Class discussion of reading material. (Soc. Sci.)

GER 2002. Introduction to Modern German Culture II
3-0-3. Prerequisite: GER 1003 or equivalent.
Continuation of GER 2001. (Soc. Sci.)

GER 2003. Introduction to Modern German Culture III
3-0-3. Prerequisite: GER 1003 or equivalent.
Continuation of GER 2002. (Soc. Sci.)

GER 2051. Issues in Science and Technology I
3-0-3. Prerequisite: GER 1003 or equivalent.
Reading, analysis, and discussion of German texts dealing with past and present issues in the natural and social sciences. (Soc. Sci.)

GER 2052. Issues in Science and Technology II
3-0-3. Prerequisite: GER 2051 or equivalent.
Continuation of GER 2051 (Soc. Sci.)

GER 2053. Issues in Science and Technology III
3-0-3. Prerequisite: GER 2052 or equivalent.
Continuation of GER 2052; addition of individual projects to conform to the students' special fields of study. (Soc. Sci.)

GER 3001. Introduction to German Literature I
3-0-3. Prerequisite: GER 2003 or equivalent.
Literary masterpieces in German. Period: Medieval times to 1750. (Hum.)

GER 3002. Introduction to German Literature II
3-0-3. Prerequisite: GER 2003 or equivalent.
Literary masterpieces in German. Period: 1750 to 1840. (Hum.)

GER 3003. Introduction to German Literature III
3-0-3. Prerequisite: GER 2003 or equivalent.
Literary masterpieces in German. Period: 1840 to the present. (Hum.)

GER 3004. German Stylistics
3-0-3. Prerequisite: GER 2003 or equivalent.
Advanced study of syntax and semantics aimed at the development of stylistic sensitivity. Analysis of representative literary works for practice in composition and conversation. (Hum.)

GER 3011. Germany Today I
3-0-3. Prerequisite: GER 2003 or equivalent.
Lectures, papers, and class discussions on German history, urban and rural morphology, postwar social and economic development in East and West Germany. (Soc. Sci.)

GER 3012. Germany Today II
3-0-3. Prerequisite: GER 2003 or equivalent.
Continuation of GER 3011; treatment of additional topics—German family life, educational system, church and religion, development of the arts, the Hitler era. (Soc. Sci.)

GER 3013. Germany Today III
3-0-3. Prerequisite: GER 2003 or equivalent.
Continuation of GER 3011 and 3012; in-depth treatment of contemporary issues. Supplementary instructional media: slides, recordings, journals, and panel discussions. (Soc. Sci.)

GER 3031. The German Novelle I
3-0-3. Prerequisite: GER 2003 or equivalent.
Period: 1795-1840. Goethe, Kleist, Tieck, Arnim, E. T. A. Hoffmann, Eichendorff. Conducted in German. (Hum.)

GER 3032. The German Novelle II
3-0-3. Prerequisite: GER 2003 or equivalent.
Period: 1840 to 1885. Stifter, Keller, Storm, Ebner-Eschenback, Meyer. Conducted in German. (Hum.)

GER 3033. The German Novelle III
3-0-3. Prerequisite: GER 2003 or equivalent.
Period: 1885 to the present. Hofmannsthal, Mann, Kafka, Musil, Wiechert, Borchert, Gaiser, Piontek. Conducted in German. (Hum.)

GER 3041. German Radio Drama I
3-0-3. Prerequisite: GER 2003 or equivalent.
German radio drama as a literary genre. Study of works of representative dramatists. (Hum.)

GER 3042. German Radio Drama II
3-0-3. Prerequisite: GER 2003 or equivalent.
An in-depth study of the works of Gunter Eich. (Hum.)

GER 3051. The German Folksong
3-0-3. Prerequisite: GER 2003 or equivalent.
Introduction to the wide range of human experience reflected in the German folksong. Emphasis on the appreciation of musical forms and literary aspects. (Hum.)

GER 4001. German Writers of the Twentieth Century I
3-0-3. Prerequisite: GER 3003 or equivalent.

Period: Naturalism to 1920. Conducted in German. (Hum.)

GER 4002. German Writers of the Twentieth Century II
3-0-3. Prerequisite: GER 3003 or equivalent.
Period: 1920 to the present. Conducted in German. (Hum.)

GER 4003. Modern German Drama
3-0-3. Prerequisite: GER 3003 or equivalent.
A study of the leading German dramatists from the period of Naturalism to the present. Lectures, parallel readings, discussions. Conducted in German. (Hum.)

GER 4023. Selected Readings in German Literature
3-0-3. Prerequisite: GER 2003 or equivalent.
Study of selected authors, movements, genres, and forms in German literature. Selections vary from year to year. Parallel readings, reports, and papers. (Hum.)

GER 4901-2. Special Problems in German
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

INTERNATIONAL INTERCULTURAL STUDIES PROGRAM
For information concerning these courses, students should contact the International Intercultural Studies Program Office of the University System of Georgia.

IISP 2950. International Intercultural Studies Program
Up to fifteen quarter credit hours per term. To be arranged.
Introductory language and/or civilization abroad. Designed primarily for freshmen and sophomores or those at the initial stages of a foreign language. An internship may be a component of the course.

IISP 3960. International Intercultural Studies Program
Up to fifteen quarter credit hours per term to be arranged.
Introductory level of study of language, civilization, business, or science abroad. Designed primarily for juniors and seniors or those placing at this level. An internship may be a component of the course.

IISP 4970. International Intercultural Studies Program
Up to fifteen quarter credit hours per term. To be arranged.
Advanced study of language, civilization, business, or science abroad. Designed primarily for students placing at this level, including postgraduate or graduate students not concentrating in the discipline for which they seek credit. An internship may be a component of the course.

ITALIAN
See FL 1021 and 2021.

LINGUISTICS

LING 1001. Fundamentals of Phonology
3-0-3.

English pronunciation contrasted with that of various foreign languages; vocabulary building; readings in linguistics. (Hum.)

LING 1002. Fundamentals of Morphosyntax
3-0-3.
Theoretical and practical approach to the study of English word and sentence formation using comparative data from different dialects and languages; grammar, punctuation, composition; readings in linguistics. (Hum.)

LING 1003. Fundamentals of Semantics, Stylistics, and Sociolinguistics
3-0-3.
A theoretical and practical approach to English semantic structure and stylistic levels; composition; readings in linguistics. (Hum.)

LING 2001. Introduction to Language I
3-0-3.
Study of the design of natural language, with emphasis on the traditional description of its phonological and grammatical systems. (Hum.)

LING 2002. Introduction to Language II
3-0-3. Prerequisite: LING 2001 or consent of the Department.
Introduction to modern grammatical and semantic theories of language. (Hum.)

LING 2003. Introduction to Language III
3-0-3. Prerequisite: LING 2002 or consent of the Department.
Survey of the types of linguistic change and development, comparison of generic and genetic linguistic relationships, linguistic borrowing. (Hum.)

LING 3001. Introduction to Articulatory Phonetics
3-0-3. Prerequisite: LING 2003 or consent of the Department.
Introduction to articulatory and acoustic phonetics, methodology for analyzing sounds in various languages, with emphasis on recording sounds in phonetic script and reproduction of sounds. (Hum.)

LING 3002. Introduction to Structural Linguistics I
3-0-3. Prerequisite: LING 3001 or consent of the Department.
Methodology for phonological analysis of language, examination of phonological data from hypothetical and natural languages. Collateral readings, problems. (Hum.)

LING 3003. Introduction to Structural Linguistics II
3-0-3. Prerequisite: LING 3002 or consent of the Department.
Continuation of LING 3002, with emphasis on morphology and syntax, study of the works of Bloomfield, Pike, and Harris. Collateral readings, problems. (Hum.)

LING 3004. Natural Language Processing
3-0-3.
Primarily for ICS students; study of selected topics from grammar and semantics that are important in the understanding and processing of natural language in human and computer contexts. (Hum.)

LING 3005. Black English Linguistics
3-0-3. Prerequisite: LING 2001 or equivalent.

Origins and development of American Black English from the 1600s to the present. Includes analysis of its structure and its relationship to African languages and cultures. (Hum.)

LING 4001. History of Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of the Department.
Survey of the theoretical developments in linguistic science, with major emphasis on the developments of the nineteenth and early twentieth centuries. (Soc. Sci.)

LING 4002. Current Developments in Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of the Department.
Live issues in the field and approaches favored by various contemporary schools. (Hum.)

LING 4003. Semantics and Linguistic Structure
3-0-3. Prerequisite: prior study of linguistics or consent of the Department.
Various approaches to the problem of dealing with meaning in linguistic analysis. (Hum.)

LING 4021. Contrastive Language Systems
3-0-3. Prerequisites: LING 3001-2-3 or consent of the Department.
A comparison of the similarities and differences of selected major languages with English in respect to phonology, written representation, syntactic, and semantic categories.

LING 4075-6-7. Comparative Analysis of Major European Languages I, II, III
3-0-3 each. Prerequisites: LING 3001-2-3 or consent of the Department.
Emphasis on grammatical and semantical structure and their correspondences, English as the control language. LING 4075 treats the major Slavic languages. LING 4076 treats the major Germanic languages. LING 4077 treats the major Romance languages.

LING 4901-2. Special Problems in Linguistics
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

PORTUGUESE
See FL 1011 and 2021.

RUSSIAN

RUSS 1001. Elementary Russian I
3-2-4.
Pronunciation, essential principles of Russian grammar, acquisition of vocabulary through illustrative readings, intensive familiarization with recorded material. (Hum.)

RUSS 1002. Elementary Russian II
3-2-4. Prerequisite: RUSS 1001 or equivalent.
Continuation of RUSS 1001, introduction of additional reading material as progress of class permits. (Hum.)

RUSS 1003. Elementary Russian III
3-2-4. Prerequisite: RUSS 1002 or equivalent.
Continuation of RUSS 1002. Emphasis on the reading of simple prose. (Hum.)

RUSS 2001. History and Culture of Russia I
3-0-3. Prerequisite: RUSS 1003 or equivalent.
Period: Ninth century to eighteenth century. Review of grammar and oral practice. (Soc. Sci.)

RUSS 2002. History and Culture of Russia II
3-0-3. Prerequisite: RUSS 1003 or equivalent.
Period: Eighteenth century to 1917. Review of grammar and oral practice. (Soc. Sci.)

RUSS 2003. History and Culture of Russia III
3-0-3. Prerequisite: RUSS 1003 or equivalent.
Period: 1917 to the present. Review of grammar and oral practice. (Soc. Sci.)

RUSS 4901-2. Special Problems in Russian
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

SPANISH

SPAN 1001. Elementary Spanish I
3-0-3.
The beginning course. Pronunciation, grammar, reading, composition. Conversations with student assistants who are native speakers of Spanish. (Hum.)

SPAN 1002. Elementary Spanish II
3-0-3. Prerequisite: SPAN 1001 or equivalent.
Continuation of SPAN 1001. (Hum.)

SPAN 1003. Elementary Spanish III
3-0-3. Prerequisite: SPAN 1002 or equivalent.
Continuation of SPAN 1002. (Hum.)

SPAN 2011. Discovery and Conquest of the New World, 1492 to 1600
3-0-3. Prerequisite: SPAN 1003 or equivalent.
The voyages of discovery and expeditions of conquest in sixteenth century Spanish America, with an introduction to the important Indian civilizations. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

SPAN 2012. Colonial Spanish America and the Wars of Independence, 1600 to 1900
3-0-3. Prerequisite: SPAN 1003 or equivalent.
Spanish America from the period of the vice-royalties and Caribbean pirates to the Wars of Independence in the 1800s. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

SPAN 2013. Twentieth Century Spanish America
3-0-3. Prerequisite: SPAN 1003 or equivalent.
Twentieth century Spanish America as a fusion of Spanish and native traditions, focusing on selected aspects of contemporary life in the Latin American countries. Conducted in Spanish. (Soc. Sci.)

SPAN 3001. Spanish-American Literature before 1895
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Conducted in Spanish. (Hum.)

SPAN 3002. Spanish-American Literature since 1895
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Conducted in Spanish. (Hum.)

SPAN 3003. Introduction to Spanish Literature
3-0-3. Prerequisite: SPAN 2013 or equivalent.

The cultural heritage of Spain in the Americas as reflected in representative European and Spanish-American literary works. Conducted in Spanish. (Hum.)

SPAN 3004. Cultural History of Mexico
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Readings from representative authors. Vocabulary building, lectures, discussions, conversation, and composition. (Soc. Sci.)

SPAN 3005. Contemporary Latin America
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Selected contemporary essays, speeches, and diverse documents reflecting social, economic, and political problems. Conducted in Spanish. (Soc. Sci.)

SPAN 3006. Grammar Review and Composition
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in Spanish. (Hum.)

SPAN 3007. Cultural History of Spain I
3-0-3. Prerequisite: SPAN 2013 or equivalent.
History of Spanish civilization from prehistoric times to 1500. Conducted in Spanish. (Soc. Sci.)

SPAN 3008. Cultural History of Spain II
3-0-3. Prerequisite: SPAN 2013 or equivalent.
History of Spanish civilization from Charles I to the Spanish-American War of 1898. Conducted in Spanish. (Soc. Sci.)

SPAN 3009. Cultural History of Spain III
3-0-3. Prerequisite: SPAN 2013 or equivalent.
Contemporary essays, speeches, and diverse documents reflecting social, economic, and political problems of this century. Conducted in Spanish. (Soc. Sci.)

SPAN 3011. The Short Story in Spain
3-0-3. Prerequisite: SPAN 2013 or equivalent.
The short story in the literature of Spain from the Middle Ages to the twentieth century. Includes authors such as Cervantes, Valle-Inclan, Cela, and Matute. (Hum.)

SPAN 3012. The Latin American Short Story
3-0-3. Prerequisite: SPAN 2013 or equivalent.
The short story in Latin America both as a literary genre and as an instrument of social revolution, includes authors such as Echeverria, Dario, Lillo, and Borges. (Soc. Sci.)

SPAN 4007. Spanish Historical Linguistics
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on phonology and morphology treated descriptively and comparatively. Brief survey of the historical development of the Spanish language. Conducted in Spanish. (Soc. Sci.)

SPAN 4008. *Libro de buen amor*
3-0-3. Prerequisite: SPAN 4007 or equivalent.
Detailed historical, linguistic, and literary analysis of the Ruiz masterpiece as the vortex of Spanish medieval civilization. Conducted in Spanish. (Soc. Sci.)

SPAN 4009. *Don Quixote*, Part I
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Detailed historical study of Cervantes' masterpiece as the vortex of Spanish literature, the prototype of the

modern novel, and the essence of Renaissance and Baroque culture. Conducted in Spanish. (Soc. Sci.)

SPAN 4010. *Don Quixote*, Part II
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Continuation of SPAN 4009. (Soc. Sci.)

SPAN 4021. Spanish Drama before 1700
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on Lope de Vega and Calderon. Conducted in Spanish. (Hum.)

SPAN 4022. Spanish Drama from 1700 to 1920
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on Neo-classicism, romanticism, and the Generation of 1898. Conducted in Spanish. (Hum.)

SPAN 4023. Spanish Drama since 1920
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on Garcia Lorca and Casona. Conducted in Spanish. (Hum.)

SPAN 4024. Spanish Prose before 1700
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on the Celestina. Conducted in Spanish. (Hum.)

SPAN 4025. Spanish Prose from 1700 to 1920
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on precursors and members of Generation of 1898. Conducted in Spanish. (Hum.)

SPAN 4026. Spanish Prose since 1920
3-0-3. Prerequisite: SPAN 3006 or equivalent.
Emphasis on Spanish writers since the advent of the Franco regime. Conducted in Spanish. (Hum.)

SPAN 4031. Latin American Novel I
3-0-3. Prerequisite: SPAN 3003 or equivalent.
Emphasis on development of Latin American novel of social concern and its relation to the political and social climate. Detailed study of various nineteenth-century and early twentieth-century masterpieces. Conducted in Spanish. (Hum.)

SPAN 4032. Latin American Novel II
3-0-3. Prerequisite: SPAN 3003 or equivalent.
The Latin American novel since World War II. Emphasis on social and literary aspect of novels of the "boom" period. Represented are authors such as Garcia Marquez, Vargas Llosa, Carpentier, and Fuentes. Conducted in Spanish. (Hum.)

SPAN 4901-2. Special Problems in Spanish
Credit to be arranged. Prerequisite: consent of the Department.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

Department of Music

Department Head and Director of Choral Activities—Gregory Colson; *Director of Bands*—Bucky Johnson; *Conductor of the Jazz Studies and String Ensemble*—Ron Mendola.

General Information

Music activities at Georgia Tech have traditionally centered around three enthusiastic and well-known performing groups: Band, Chorale, and Jazz Ensemble. Although the Institute does not offer a degree in music, participants earn academic credit that counts toward free-elective and humanities requirements. Recent expansions in course offerings allow additional musical opportunities. Specific offerings should be checked each quarter in the On-Line Student Computer-assisted Registration booklet. The Department plans its events with awareness of other demands upon Tech students so that a great amount of musical experience is concentrated into a limited time. Financial assistance is available for students who serve the Department in various duties. The Music Department is housed in the Couch Building, located on the West campus.

The Marching Yellow Jackets, Pep Band, and Concert Band are all elements of the Georgia Tech Band Program. Since its inception in 1908, it has fulfilled two primary goals: to support the Institute and to provide a musical outlet for Tech students. The Marching Band and Pep Band travel to several out-of-state events, including the ACC Tournament, football games, and bowl appearances. These trips are financed by the Athletic Association. A limited number of scholarships are available to band students.

The Chorale, a singing group that combines the well-known men's glee club with the newer women's chorus, undertakes an ambitious series of classical, sacred, and popular music performances on campus, in the Atlanta area, and in neighboring states on a spring-break tour. They have been featured in concerts of sacred masterworks with the Atlanta Symphony, in pops concerts with combos and the Jazz Ensemble, at Epcot and Walt Disney World and in opera productions. In addition to rehearsal and performance, Chorale members learn vocal technique and music history.

The Georgia Tech Jazz Ensemble, a traditional twenty-piece band, has established a strong reputation through numerous local appearances. After meeting the prerequisite of a satisfactory audition, members are involved in rehearsals, recording sessions, and performances. The level of performance achieved has won two jazz festivals and the respect of the Atlanta music community.

Special topics presently being offered include String Ensemble, Brass Ensemble, Dixieland Band, and Computer Music courses. Additional information is available from the Department of Music.

Courses of Instruction

MUSI 1111, 2111, 3111, 4111. Marching Band
0-6-2. Prerequisite: past instrumental experience and consent of the director for the first course.

MUSI 1102-3, 2102-3, 3102-3, 4102-3. Concert Band
0-3-1. Prerequisite: past instrumental experience and consent of the director for the first course.

MUSI 1201-2-3-4, 2201-2-3-4, 3201-2-3-4, 4101-2-3-4. Chorale—Mixed Singing Group
0-3-1. Prerequisite: past vocal experience and consent of the director for the first course.

MUSI 1301-2-3, 2301-2-3, 3301-2-3, 4301-2-3. Jazz Ensemble
0-3-1. Prerequisite: past instrumental experience and consent of the director for the first course.

MUSI 3400. Composers and Their Music
2-0-2. A survey of the historical periods of music with lecture, discussion, and recorded examples.

MUSI 3800. Special Topics—Music
0-2-1. Sections offered in various quarters include String Ensemble, Brass Ensemble, Percussion Ensemble, Dixieland, Vocal Ensemble, and Computer Music.

Department of Naval Science
Established in 1926

Commanding Officer and Professor of Naval Science—Captain Dennis Y. Sloan, USN; *Associate Professor*—Commander H. M. Lewandowski, USN; *Assistant Professors*—Major C. K. Curcio, USMC; Lieutenant Mark Johnson, USNR; Lieutenant David Pilcher, USN; Lieutenant William R. Gideon, USN; Lieutenant G. P. Arnold, USN; Lieutenant Joe Maynard, USN.

General Information

The naval officer education program offers students the opportunity to qualify for service as commissioned officers in the United States Navy or Marine Corps. The program consists of a standardized curriculum designed to complement and assist academic pursuits of imparting knowledge of the naval environment and fostering an understanding of the role of the Navy and Marine Corps in national security. Upon graduation, the student is commissioned and ordered to the Marine Corps or to active duty involving flying, submarine warfare, or surface warfare.

Students in the program are enrolled in one of the three categories outlined below. The Department conducts an orientation period for all new NROTC scholarship students during registration week prior to the fall quarter.

Scholarship Students

Scholarship students are selected after nationwide competition. The Navy pays for their tuition, fees, and textbooks for a period of four years. The government also provides uniforms and a subsistence allowance of $100 per month. At the end of one year, students must obligate themselves to complete the prescribed naval science curriculum; to make a cruise of four to eight weeks each summer; to accept a commission as Ensign, USN, or Second Lieutenant, USMC, upon graduation; and to serve on active duty for four years after commissioning unless released earlier by the Navy Department.

College Program Students

College program students are enrolled under the provision of Public Law 86-647. Students can enter the college program during the freshman year, or upon qualification, prior to April 1 of the sophomore year. Prior to starting the junior year, the college program student must enlist in the United States Naval Reserve for a period of eight years. The student must agree to serve on active duty for not less than three years after appointment to commissioned rank in the Naval Reserve or Marine Corps Reserve and to retain that commission until the sixth anniversary of receipt of the original commission.

College program students receive uniforms at government expense and during their junior and senior years receive subsistence allowance of $100 per month. They must complete the prescribed naval science curriculum, make a cruise of approximately six weeks during the summer after the junior year, and upon graduation accept a commission as Ensign, USNR, or Second Lieutenant, USMCR. If they desire, after receiving their reserve commission, college program students may apply for a commission in the regular Navy or Marine Corps.

Two-year Program

Sophomores may apply and compete nationally for two-year NROTC scholarships. The NROTC at Georgia Tech has no part in the selection process although information and counseling are available. Those selected for either the Two-year College Program or Two-year NROTC Scholarship attend eight weeks of active duty training during the summer between the sophomore and junior years so they can join their classmates on an equal footing in the junior year naval science classes.

Selection Procedures

Four-year scholarship students are selected in nationwide competition based on SAT or ACT scores, high school performance, extracurricular activities, and interests. The selection process is administered by the Naval Recruiting Command; however, the NROTC unit will provide information and guidance. The professor of naval science may nominate well-qualified college program students to the Chief of Naval Education and Training for scholarships ranging from one to three and one half years; academic performance at Georgia Tech is the primary selection criterion for these scholarships. Freshmen attending Georgia Tech or other Atlanta-area higher education institutions that have cross-enrollment agreements may apply for the College Program. Applicants may apply at the Naval Armory at any time; however, it is most desirable to apply during freshman orientation or early freshman year.

Curriculum

In addition to the required naval science courses, all Navy Option Scholarship Students must take calculus (MATH 1307-8 or MATH 1317-8), physics (PHYS 2121 or 2141

series), POL 3203 and 3204, and one term of computer science. Marine Option students must also take POL 3203 and 3204 or a substitute approved by the professor of naval science. Any additional requirements are based on whether the student is in a technical or nontechnical major, is in Navy Option or Marine Option, and is a scholarship or nonscholarship student. Each student must obtain from the NROTC Department a complete description of program requirements since the above statement is only a general outline.

No more than six hours of credit in basic naval science·courses and no more than nine hours of credit in advanced naval science courses will be applied toward degree requirements.

Courses of Instruction

NS 1001. Naval Organization and Sea Power
2-1-2.
Introduction to structure and principles of naval organization, terminology, customs and uniforms, missions of the Navy as they relate to sea power and maritime affairs.

NS 1002. Naval Ship Systems I
2-1-2.
Discussion of naval ship design and construction. Examination of concepts and calculations of ship stability characteristics. Introduction to shipboard damage control.

NS 1003. Naval Ship Systems II
2-1-2. Prerequisite: NS 1002.
Shipboard propulsion, electrical, and auxiliary engineering systems are examined. Nuclear propulsion, gas turbines, and other developments in naval engineering are presented.

NS 2012. Seapower and Maritime Affairs
2-1-2.
The broad principles, concepts, and elements of the topic, with historic and modern applications to the United States and other nations.

NS 2013, Naval Weapons Systems I
2-1-2.
A fundamental working knowledge of weapon system components and their contribution to the overall system is provided. The relationships of systems and subsystems are explored.

NS 2014. Naval Weapons Systems II
2-1-2. Prerequisite: NS 2013.
Employment and utilization of naval weapons systems are studied. An understanding of the capabilities of weapons systems and their role in the Navy's mission.

NS 3001. Navigation I
3-2-3.

Theory and technique of navigation at sea. Areas of emphasis include dead reckoning, piloting, rules governing waterborne traffic. Practical applications utilizing nautical charts, tables, and instruments.

NS 3002. Navigation II
3-2-3. Prerequisite: NS 3001 or consent of the Department.
Determination of position at sea using the marine sextant to observe heavenly bodies, principles, applications. Utilization of advanced electronic navigation systems is also introduced.

NS 3003. Naval Operations
3-2-3. Prerequisite: NS 3002. NROTC students only.
Elements and principles of naval operations. Command responsibility, tactical doctrine, communication procedures, and relative movement problems introduced. Practical applications include review of basic navigation techniques.

NS 3005-6. Evolution of Warfare I and II
3-2-3 each.
Two-quarter sequence explores forms of warfare practiced by great peoples in history. Selected campaigns are studied, with emphasis on impact of leadership, evolution of tactics, weaponry, and principles of war.

NS 4004-5. Amphibious Warfare I and II
3-2-3 each.
Two-quarter sequence designed to study projection of seapower ashore, with emphasis on evolution of amphibious warfare in the twentieth century. Strategic concepts, current doctrine discussed.

NS 4101. Naval Leadership and Management I
3-1-3.
Survey of the development of managerial thought through functional, behavioral, and situational approaches. Managerial functions, communication, and major theories of leaders and motivation applied to the Navy organization. Accountability of the naval officer for the performance of both subordinates and technical systems is emphasized. MGT 3100, 3150, 4100, ISYE 3105, or SOC 3335 may be scheduled to satisfy this requirement.

NS 4102. Naval Leadership and Management II
2-1-2.
Discussion of the administrative duties and responsibilities of the junior naval officer for personnel management and division discipline. Includes study of significant features of Navy regulations and military law and detail in the areas of enlisted performance evaluation, advancement, and service records.

NS 4103. Naval Leadership and Management III
2-1-2.
Introduction to the Navy Human Resources Management Support System. The junior naval officer's duties and responsibilities for material maintenance and personnel training. Seminars in elements of personal affairs planning, including finance, orders, benefits, travel, and related topics.

Department of Physical Education and Recreation
Established in 1942

Department Head and Professor—James A. Reedy; *Associate Professors*—Bill D. Beavers, Phillip B. Sparling; *Assistant Professors*—Douglas L. Fowlkes, David W. Houser, Mindy Millard-Stafford; *Instructors*—Rhonda E. Campbell, Carlos L. DeCubas, Linda S. DiCarlo, Gery W. Groslimond, James P. Hebron, Kirk D. McQueen, Linda C. Rosskopf, Judy Sackfield, Jeffrey C. Tinklepaugh, Patricia Tinklepaugh.

General Information
The Department of Physical Education and Recreation seeks to provide opportunities to develop new skills and gain information that will allow the student to lead a healthier and more productive life. The majority of activity and skills courses are scheduled on two alternate days per week, meeting two hours per day.

The Physical Education Requirement
All students entering Georgia Tech must satisfactorily complete the physical education requirement. The requirement should be taken during the freshman year, preferably during the initial quarter of matriculation, and consists of one three-hour course—either PE 1040 Health Education or PE 1061 Fitness: Theory, Evaluation, and Conditioning. Students who have completed their physical education requirement are encouraged to elect additional courses of interest.

A student's Health Information Record will determine any medical exemption from physical education courses. The Student Health Service must endorse all certificates of disability from personal physicians before the Department will accept them. It is suggested that students with physical disabilities enroll in PE 1040 rather than PE 1061.

The Department will grant credit to transfer students for comparable physical education courses completed at other institutions.

Courses of Instruction

PE 1005. Beginning Swimming
0-4-1.
Introduction to swimming fundamentals and safety skills. Open exclusively to nonswimmers.

PE 1010. Swimming
0-4-1.
Each student strives for maximum safety by thoughtful experimentation with simulated water emergencies. Drownproofing evolves as the basic method for survival.

PE 1020. Beginning Gymnastics
0-4-1.
Gymnastic movement is used to develop essential elements of fitness, including flexibility, coordination, strength, balance, and kinesthetic awareness. Open to both sexes.

PE 1030. Women's Gymnastics
0-4-1.
Instruction, demonstration, and practice of basic women's gymnastics skills utilizing the four Olympic women's events. Flexibility and general physical conditioning exercises are included.

PE 1040. Health Education
3-0-3.
Guest lecturers from the medical and allied health profession(s) acquaint the student with contemporary personal health concerns, including drugs, nutrition, emotional health, and sex ·education.

PE 1050. Aerobic Conditioning: Running
0-4-1.
Primary emphasis on improvement of endurance and cardiovascular and respiratory system efficiency through an individually tailored program of jogging/running.

PE 1061. Fitness: Theory, Evaluation, and Conditioning
2-2-3.
Basic concepts on which lifetime fitness programs are founded. Role of exercise in health, weight control, and quality of life. Assessment of personal fitness and individualized exercise program for each student. Combination of lectures, laboratory demonstrations, and conditioning activities.

PE 1070. Aerobic Dance
0-4-1.
Improvement of flexibility, strength, and primarily cardiorespiratory endurance through basic dance exercises. Course components also include fitness assessment and weight control.

PE 1090. Physical Conditioning: Strength Training
0-4-1.
Instruction, demonstration, and practice of basic physical conditioning with emphasis on muscular strength. Activities include running, stretching, calisthenics, circuit training, and weightlifting.

PE 2020. Intermediate and Advanced Gymnastics
0-4-1. Prerequisite: PE 1020 or 1030 or prior gymnastics experience.
Development of gymnastics skills beyond the beginning levels. Instruction in the ten international competitive events for men and women and acrobatics is included.

PE 2050. Beginning Tennis
0-4-1.
Designed for the beginning player. Introduction to fundamentals; ground strokes, basic serve, and volley. Rules and etiquette included.

PE 2051. Intermediate Tennis
0-4-1.
Concentration on intermediate skills, stroke refinement, spins, singles and doubles strategy.

PE 2060. Volleyball
0-4-1.
The serve, spiking, passing, team defensive and offensive play will be demonstrated and practiced, after which team competition is organized.

PE 2070. Racquetball
0-4-1.
Singles and doubles competition follows basic fundamentals and offensive and defensive strategies.

PE 2080. Bowling
0-4-1.
Team and league bowling competition follows an instructional program utilizing both live and filmed demonstration of basic skills and techniques.

PE 2110. Basketball
0-4-1.
Instruction and practice in basic fundamentals followed by team competition.

PE 2130. Soccer
0-4-1.
Organization of teams and competition follows skills practice and demonstration of offensive and defensive strategy.

PE 2150. Lifeguard Training
0-4-1.
Formerly Advanced Lifesaving. Course leads to Red Cross certification. Class covers preventive lifeguarding, rescues, carries, pool management and maintenance.

PE 2160. Water Safety Instructor Course
1-3-2. Prerequisites: current CPR/First Aid certificate, advanced lifesaving certificate, and pass precourse skills requirement.
Course leads to Red Cross certification in Advanced Lifesaving and Swimming.

PE 2170. Cardiopulmonary Resuscitation and Standard First Aid
0-4-1. '
Basic CPR and emergency first aid skills designed to lead student to Red Cross certification.

PE 2180. Weight Control Through Diet and Exercise
0-4-1.
Designed to assist individuals with weight reduction through modification of eating habits and activity patterns. The course promotes immediate and long-term weight control.

PE 3100. Exercise Physiology
3-3-4. Prerequisites: junior standing and freshman natural science or consent of the Department.
An introduction to the physiological effects of human physical activity. Topics include neuromuscular, cardiovascular-respiratory, and metabolic responses and adaptations to exercise.
This course is exempted from the six-hour limit on PE credit that may be counted toward graduation and may be used as a free or technical elective with the consent of the major department.

PE 3801-2-3-4. Special Topics in Exercise Science
Credit hours equal last digit of course number. Prerequisite: consent of the instructor.
Current topics in exercise science are presented as demand or interest warrants.

PE 3901-2-3-4. Special Problems in Exercise Science
Credit to be arranged. Prerequisite: consent of laboratory faculty member.
Student projects conducted in the Exercise Science Laboratory under the direction of a faculty exercise physiologist. Exposure to research investigation including laboratory procedures and instrumentation.

School of Physics
Established in 1939

Director and Professor—Edward W. Thomas; *Associate Director for Graduate Programs and Professor*—Ronald F. Fox; *Assistant Director for Undergraduate Programs and Professor*—Helmut Biritz; *Regents' Professors*—Charles H. Braden, Joseph Ford, Harold A. Gersch; *Professors* —R. Martin Ahrens, C. F. Barnett (adjunct), Christopher Bottcher (adjunct), David Finkelstein, Martin R. Flannery, Ian R. Gatland, James L. Gole, Don S. Harmer, Donald E. Kinkaid (adjunct), Uzi Landman, David W. Martin, Eugene T. Patronis, Jr., Augustus L. Stanford, James R. Stevenson, Jr., Henry S. Valk, Roger M. Wartell, Michael K. Wilkinson (adjunct), R. A. Young; *Associate Professors*—Harry G. Dulaney, David B. Dusenbery, Tai-Huang Huang, Donald C. O'Shea, James M. Tanner, Richard M. Williamon (adjunct), John L. Wood, Andrew Zangwill; *Assistant Professors*—Akit B. Balentekin (adjunct), Ahmet Erbil, David L. Fuller (adjunct), Rajarshi Roy, A. Turgay Uzer; *Principal Research Scientist*—Christopher Summers; *Senior Research Scientist*—Fred L. Eisele; *Research Scientists II*—Robert N. Barnett, James R. Cagle, Charles L. Cleveland, Vincent Mallette, Edmund J. Mansky, Martin W. Ribansky; *Research Scientist I*—James R. Woodward.

General Information
Physics is primarily a basic science, and fundamental research into the principles of physics continues to occupy the attention of many physicists. The study of physics has also become increasingly important as a basis for fundamental research in interdisciplinary areas such as biophysics and chemical physics and as an applied science in government and industry. Furthermore, as society becomes more technically oriented, an education in physics may provide an advantageous preprofessional foundation.

The School of Physics offers basic service courses to freshmen and sophomores, some advanced service courses for students of engineering, science, and mathematics, and advanced work leading to the bachelor's, master's, and doctoral degrees in physics. The School seeks to provide elective freedom in its undergraduate and graduate degree programs in order to enable students with a wide variety of interests to work out suitable programs of study.

In addition to offering courses in the fundamentals of physics, the School provides numerous specialized courses at the undergraduate and graduate levels, especially in areas related to the research interests of the faculty. Current faculty research interests include acoustics, atomic physics, computer science, elementary particles, general relativity, many-body theory, molecular physics, nuclear physics, optics and laser physics, quantum logic, solid-state physics, statistical mechanics, physics instruction, and interdisciplinary areas in biophysics and materials science. Opportunities exist in these areas, as well as in some other areas by collaboration with faculty members of other schools and departments, for undergraduate and graduate special problems, master's theses, and doctoral dissertations.

Information supplementary to this catalog that may be useful to students in the planning of programs of study is available from the School of Physics. A graduate brochure, which further describes the opportunities for graduate study and research, is available upon request. Students majoring in physics should consult frequently with their faculty advisers. Any student who does not have an adviser should contact the School office.

Undergraduate Programs
The School of Physics offers two undergraduate degrees, the Bachelor of Science in Physics and the Bachelor of Science in Applied Physics. The basis of the former degree program is the traditional preparation of a student for graduate study in physics. The degree program in applied physics may be better suited for entry into industry or government upon graduation, preparation for further professional training (medicine, law, dentistry, or business), or preparation for graduate study in some other discipline. The two degree programs differ in that a few courses intended primarily as preparation for graduate study in physics in the traditional program are replaced by courses oriented toward the applications of physics in the applied physics program. Greater flexibility in the choice of technical electives is available in the applied physics program.

Each of the baccalaureate programs contains the following: (a) courses needed to meet general institutional degree requirements; (b) a core of technical courses intended to give a strong background in mathematics and in the physical principles of mechanics, electricity and magnetism, thermodynamics, and the quantum theory that governs physical phenomena at the microscopic level of molecules, atoms, and nuclei; (c) technical electives that enable the student to explore areas of his or her choice in greater depth; and (d) free electives, about one-fifth of the total hours, which may be employed to schedule additional technical or nontechnical courses.

The considerable flexibility inherent in the physics curricula is advantageous to students who wish to work out individual programs of study. At the same time, this flexibility suggests the need for consultation with advisers so students can make the best use of elective hours and can avoid scheduling difficulties that may arise in later quarters.

Since many students who earn a degree in physics have transferred from another discipline, the School has planned the degree

programs to enable most students to transfer into physics with little or no loss of credit.

A total of 190 credit hours and a grade point average of at least 2.0 in physics courses numbered 3000 and higher are requisites for the bachelor's degree in physics.

Students may utilize their elective freedom in the physics curricula to specialize in particular areas of physics, to prepare for careers in interdisciplinary areas of science, to compose a preprofessional program, or to gain a background in other technical or nontechnical disciplines. For assistance to students in planning programs of study with emphasis directed toward a particular objective, the School has formulated suggestions for the use of elective hours. Supplementary material, available from the School office or from faculty advisers, includes suggestions relevant to the following areas of study: graduate study in physics, acoustics, applied optics, biophysics, computational physics, computer-based instrumentation, geophysics, and solid-state physics. A candidate for either baccalaureate degree in physics need not follow any one of these suggested areas of study but may combine features of several programs or devise individual programs of study.

Attention is also directed to the possibility of using elective hours for special problems (PHYS 3900-1-2 or 4900-1-2) conducted under the supervision of a faculty member.

Certificate Programs in Physics

The School of Physics offers programs of study leading to certificates in Applied Optics and in Computer-based Instrumentation. The purpose of the programs is to prepare students for careers in industry where basic physical understanding is applied to the solution of technological problems. Course requirements, which are fulfilled in the junior and senior years, are detailed in brochures available from the School. The applied physics degree program is often used by students who seek certificates offered by the School of Geophysical Sciences. Details may be obtained from that school.

Bachelor of Science in Physics Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
CHEM 1101-2			
or			
CHEM 1111-2			
General Chemistry	4-3-5	4-3-5	.....
PHYS 2121			
General Physics	.....	.....	4-3-5
ENGL 1001-2			
Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2XXX			
English Elective			
	.....	.....	3-0-3
Social Sciences or Humanities Electives	3-0-3	3-0-3	3-0-3
Physical Education			
(requirements, p. 253)	.....	.....	X-X-3
TOTALS	15-3-16	15-3-16	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 2307-8			
Calculus IV, V	5-0-5	5-0-5	.....
MATH 2309 or 3308			
Differential Equations	.....	.....	5-0-5
PHYS 2122-3			
General Physics	4-3-5	4-3-5	.....
Social Sciences Electives	3-0-3	3-0-3	3-0-3
Humanities or Social Sciences Electives	3-0-3	3-0-3	3-0-3
Free Electives	.....	.....	6-0-6
TOTALS	15-3-16	15-3-16	11-0-17

Junior and Senior Years

Course	Credit Hours
PHYS 3121-2-3	
Classical Mechanics, Electricity, Magnetism 15-0-15	
PHYS 3141	
Thermal Physics 5-0-5	
PHYS 3143	
Quantum Mechanics I 5-0-5	

Physics Electives
At least three laboratory courses must be included. These electives must be approved by the School of Physics and must not include more than six hours below the 3000 level X-X-20

Electives
To bring total hours to 190 .... X-X-44

TOTALS X-X-89

ELECTIVES

English Elective
ENGL 2XXX must be approved for credit toward the eighteen-hour humanities requirement. Students whose scores are sufficiently high on the College Board SAT-Verbal and the English achievement examinations may, in consultation with the Department of English, replace ENGL 1001 or 1002 with other English courses.

Humanities and Social Sciences Electives
See "Information for Undergraduate Students," pp. 41-42, for information relative to the thirty-six credit hour requirement in the humanities and the social sciences.

Students who contemplate doctoral work in physics should include study of the French, German, or Russian languages in their programs.

All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 fulfill this requirement.

ROTC
If ROTC is elected, the first course should be scheduled during the first quarter the student is in attendance. A student may schedule additional hours during the freshman year, or certain courses may be deferred in order to schedule ROTC. A maximum of fifteen hours of ROTC courses may be counted as free electives toward a degree in physics, of which no more than six hours may be in ROTC courses at the 1000-2000 level.

RECOMMENDATIONS
Students contemplating advanced work in chemistry should consider taking CHEM 1111-2 in lieu of CHEM 1101-2.

Some students, e.g., biophysics students or premedical students, will find it advisable to commence upper-level chemistry courses during their sophomore year. They should schedule CHEM 2113 in the third quarter of the freshman year and defer the start of the general physics sequence until the sophomore year.

Physics majors are encouraged to elect PHYS 1000 during the freshman year.

A course in computer programming is suggested during the freshman or sophomore years, e.g., ICS 1700, CE 3513, EE 1010, ME 2016, or PHYS 3263.

Students who have demonstrated competence in mathematics should consider substituting PHYS 2141-2-3 for PHYS 2121-2-3 and MATH 3308 for MATH 2309.

Bachelor of Science in Applied Physics Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
CHEM 1101-2			
or			
CHEM 1111-2			
General Chemistry	4-3-5	4-3-5	.....
PHYS 2121			
General Physics	.....	.....	4-3-5
ENGL 1001-2			
Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
ENGL 2XXX			
English Elective	.....	.....	3-0-3
Social Sciences or Humanities Electives	3-0-3	3-0-3	3-0-3
Physical Education			
(requirements, p. 253)	.....	.....	X-X-3
TOTALS	15-3-16	15-3-16	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 2307-8			
Calculus IV, V	5-0-5	5-0-5	.....
MATH 2309 or 3308			
Differential Equations	.....	.....	5-0-5
CHEM 2113			
Chemical Principles			
or			
PHYS 3141			
Thermal Physics			
or			
ME 3720			
Thermodynamics	.....	.....	X-0-X

PHYS 2122-3 General Physics	4-3-5	4-3-5	.....
EGR 1170 Introduction to Visual Communication and Engineering Design I	.....	2-3-3	.....
Computer Programming Elective	.....	.....	0-0-3
Social Sciences Electives	3-0-3	3-0-3	3-0-3
Humanities or Social Sciences Electives	3-0-3	3-0-3	3-0-3
TOTALS	15-3-16	17-6-19	14-3-18

Junior and Senior Years

Course	Credit Hours
PHYS 3121 Classical Mechanics	5-0-5
PHYS 3122 Classical Electricity	5-0-5
PHYS 3143 Quantum Mechanics I	5-0-5
PHYS 3211 Electronics	5-6-7

Electives
Technical electives which must include at least three laboratory courses. These technical electives need not all be in physics but they must be approved by the School of Physics and must not include more than six hours below the 3000 level X-X-25

Electives
To bring total hours to 190 .... X-X-38

TOTAL 85

ELECTIVES
English Elective
ENGL 2XXX must be approved for credit toward the eighteen-hour humanities requirement. Students whose scores are sufficiently high on the College Board SAT-Verbal and the English achievement examinations may, in consultation with the Department of English, replace ENGL 1001 or 1002 with other English courses.

Humanities and Social Sciences Electives
See "Information for Undergraduate Students," pp. 41-42 for information relative to the thirty-six credit hour requirement in the humanities and the social sciences.

All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 fulfill this requirement.

ROTC
If ROTC is elected, the first course should be scheduled during the first quarter the student is in attendance. A student may schedule additional hours during the freshman year, or certain courses may be deferred in order to schedule ROTC. A maximum of fifteen hours of ROTC courses may be counted as free electives toward a degree in physics, of which no more than six hours may be in ROTC courses at the 1000-2000 level.

Computer Programming Elective
Students should schedule one of the following courses during their freshman or sophomore year: ICS 1700, CE 3513, EE 1010, ME 2016, PHYS 3263, or other computer course approved by the School of Physics.

RECOMMENDATIONS
Students contemplating advanced work in chemistry should consider taking CHEM 1111-2 in lieu of CHEM 1101-2.

Some students, e.g., biophysics students or premedical students, will find it advisable to commence upper-level chemistry courses during their sophomore year. They should schedule CHEM 2113 in the third quarter of the freshman year and defer the start of the general physics sequence until the sophomore year. Physics majors should elect PHYS 1000 during the freshman year.

Students who have demonstrated competence in mathematics should consider substituting PHYS 2141-2-3 for PHYS 2121-2-3 and MATH 3308 for MATH 2309.

EGR 1170 may be replaced by another course with the approval of the student's academic adviser.

Graduate Programs

Master's Programs
The School of Physics offers two master's degrees, the Master of Science in Physics and the Master of Science in Applied Physics.

The Master of Science in Physics is the traditional physics degree and normally comprises the program a graduate student executes in the course of study toward a doctorate. Students may fulfill the requirements for the degree by taking forty-five hours of course work or by electing a master's thesis in lieu of fifteen hours of courses. Most students should include PHYS 6121, 6122, 6123, and 6141. Students should also include a research component either through inclusion of special problems work or by election of a thesis.

The Master of Science in Applied Physics is intended to help prepare an individual for a career in industrial, independent, or government laboratories. It is a good choice for a terminal master's degree. However, the program may serve equally well as preparation for a doctoral program. The program includes a practicum of at least twelve credit hours in an area of applied physics. Examples of available areas include acoustics, instrumentation, optics, and physical characterization of materials. Students should take courses of importance in applied physics, e.g., PHYS 4143, "Classical Mechanics II" (currently offered as a special topics course), PHYS 6132, PHYS 4262, and additional courses in support of the practicum.

Doctoral Program
The Doctor of Philosophy degree is directed toward proficiency in independent scholarly work. The degree program comprises course work in the principles of physics, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, the passing of a comprehensive examination, and an independent research investigation.

Fifteen credit hours must be earned in a minor field, which may be any approved technical or nontechnical field the student chooses in consultation with his or her adviser. A minimum of ten graduate-level courses is required. Completion of the seminar series, PHYS 8001-2-3, and four core courses, PHYS 6121-2-3 and 6141, is advisable prior to taking the comprehensive examination. Three depth courses from 6142-3, 7121-2-3, 7143 and 7147 are strongly urged, as well as three courses related to the doctoral research area. Mathematics equivalent to MATH 6501-2 is recommended for most doctoral candidates. A grade point average of 2.9 in courses taken while a graduate student is required to register for the comprehensive examination and is requisite for the degree.

The School encourages students to commence participation in a research program early in their graduate careers. The undertaking of a doctoral thesis is reserved until the comprehensive examination is passed, which should occur during the second graduate year for a well-prepared student.

Courses of Instruction

PHYS 1000. Physics Orientation
1-0-1.
Guest lectures will describe career opportunities in physics, the role physicists play in education, government, and industrial laboratories, and programs available to physics majors.

PHYS 1001. Survey of Great Advances in Modern Physics
1-0-1.
A series of lectures, each of which deals with an important area of physics research or application, e.g., superconductivity, lasers, nuclear structure and energy, transistors.

PHYS 2001. Physics of Space and Time
3-0-3. Prerequisite: PHYS 2121 or 2111.
An introduction to special and general relativity. Principle of relativity. Speed of light. Space contraction. Time dilation. Mass, momentum, and energy. Principle of equivalence.
Text: at the level of Einstein, *Relativity: the Special and the General Theory.*

PHYS 2021. Introduction to Astronomy I
3-0-3.
The nature of behavior of the earth and the other members of the solar system will be examined.
Text: at the level of Abell, *Exploration of the Universe.*

PHYS 2022. Introduction to Astronomy II
3-0-3. (PHYS 2021 is not a prerequisite for PHYS 2022.)
The nature and behavior of the stars and galaxies will be examined.
Text: at the level of Abell, *Exploration of the Universe.*

PHYS 2030. Physics of Music
3-0-3.
A descriptive introduction to the physical principles of the various sources of musical tones, how the sounds are generated, transmitted, and received by the listener.
Text: at the level of Rigden, *Physics and the Sound of Music.*

PHYS 2111-2-3. Elementary College Physics I, II, III
4-0-4 each. PHYS 2111 should be taken first; PHYS 2112 and 2113 may be taken in either order, but it is preferable that 2112 precede 2113. Credit not allowed for both 2111-2-3 and PHYS 2121-2-3 (or 2141-2-3).
This sequence of three courses treats the physical principles of mechanics; heat, wave motion, electricity,

and magnetism; light and modern physics, respectively, for students in the less technical curricula. Method of teaching and subject matter are chosen to give an understanding of scientific methods and a background of scientific information needed to comprehend the commercial, cultural, and political significance of scientific progress.

Text: at the level of Hooper and Gwynne, *Physics and the Physical Perspective*.

PHYS 2121. Particle Dynamics
4-3-5. Corequisite: MATH 1309.

Introduction to classical mechanics. Topics include kinematics, dynamics, energy, momentum, and rotational motion. Laboratory based on frictionless surfaces and stroboscopic photographic equipment emphasizes data analysis.

Text: at the level of Stanford and Tanner, *Physics for Students of Science and Engineering*.

PHYS 2122. Electromagnetism
4-3-5. Prerequisite: PHYS 2121; corequisite: MATH 2307.

Topics include electric field, potential, magnetic field, and electromagnetic induction. Calculus and vectors are used. The laboratory stresses use of electrical instruments including oscilloscopes.

Text: at the level of Stanford and Tanner, *Physics for Students of Science and Engineering*.

PHYS 2123. Optics and Modern Physics
4-3-5. Prerequisites: PHYS 2122 and MATH 2307.

Wave propagation, interference, diffraction, and polarization. Geometrical optics. Particle aspects of electromagnetic radiation and wave aspects of material particles. Bohr model. Laboratory illustrates wave propagation.

Text: at the level of Stanford and Tanner, *Physics for Students of Science and Engineering*.

PHYS 2141-2-3. General Physics I, II, III
5-3-6 each. Prerequisites: see listings for PHYS 2121-2-3.

This sequence parallels PHYS 2121-2-3; courses from the two sequences may be intermixed. In this sequence, some topics will be treated in more depth, and some additional topics will be included. These courses are intended for students with demonstrated competence in mathematics and who desire a more rigorous foundation in physics.

PHYS 2750. Physics of the Weather
3-0-3.

An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed and some elements of weather forecasting are analyzed. PHYS 2750 is the same as GEOS 2750.

Text: at the level of Battan, *Fundamentals of Meteorology*.

PHYS 2801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

PHYS 2900-1-2. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

PHYS 3001. Introductory Modern Physics
5-0-5. Prerequisite: PHYS 2123.

Survey of principles and phenomenology of modern physics, including atomic structure, nuclear phenomena, and the interaction of radiations with matter.

Text: at the level of Weidner and Sells, *Elementary Modern Physics*.

PHYS 3021. Nuclear Astrophysics and Stellar Evolution
3-0-3. Prerequisite: PHYS 2123.

Nucleosynthesis and energy generation in stars, stellar models, and stellar evolution. Formation of elements, supernovae, quasars, neutron stars, "black-holes," and radio sources. All majors.

Text: at the level of Fowler, *Nuclear Astrophysics*.

PHYS 3121. Classical Mechanics
5-0-5. Prerequisite: PHYS 2123. Corequisite: MATH 2309.

Dynamics of particles including oscillations and planetary motion, rotation of rigid bodies, collisions.

Text: Barger and Olsson, *Classical Mechanics: A Modern Perspective*.

PHYS 3122. Classical Electricity
5-0-5. Prerequisite: PHYS 2123. Corequisite: MATH 2309.

Electric and magnetic fields, potentials, resistance, indictance and capacitance, polarization, magnetic materials, development of Maxwell's equations.

Text: Cheng, *Field and Wave Electromagnetics*.

PHYS 3123. Classical Magnetism
5-0-5. Prerequisite: PHYS 3122.

Applications of Maxwell's equations, including the propagation of electromagnetic waves; electrodynamics.

Text: Wangsness, *Electromagnetic Fields*.

PHYS 3141. Thermal Physics
5-0-5. Prerequisites: PHYS 2123 and MATH 2308.

Thermodynamics and introduction to statistical mechanics. Heat, temperature, entropy. Reversible, irreversible and quasistatic processes. Thermodynamic potentials. Magnetic thermodynamics. Maxwell-Boltzmann distribution. Microcanonical and canonical ensembles.

Text: at the level of Callen, *Thermodynamics*.

PHYS 3143. Quantum Mechanics I
5-0-5. Prerequisites: PHYS 3121 and MATH 2309.

Historical approach to wave mechanics. Operator, eigenfunction—eigenvalue problem solutions to Schroedinger's equation, free particle, particle in a box, the square well, harmonic oscillator, rigid rotator and hydrogen atom.

Text: at the level of Eisberg, *Fundamentals of Modern Physics*.

PHYS 3211. Electronics
5-6-7. Prerequisite: PHYS 2123.

AC circuits; semiconductor devices; amplifiers, feedback, operational amplifiers, oscillators; introduction to digital circuits, combinatorial and sequential logic; representative experiments in the laboratory.

Text: Brophy, *Basic Electronics for Scientists*.

PHYS 3223. Geometrical Optics
3-0-3. Prerequisites: PHYS 2123 and MATH 2308.

Development of optical analysis of lenses and reflectors using matrix theory. Coverage includes image formation, stops, aberrations, photometry, and analysis of typical optical systems.

Text: at the level of Blaker, *Geometric Optics*.

PHYS 3224. Optical Instruments Laboratory
1-3-2. Corequisite: PHYS 3223.

Use of optical instruments for purposes of observation and measurement. Instrumentation includes spectrometers, interferometers, nodal slides, microscopes, and telescopes.

PHYS 3225. Fourier Optics
3-0-3. Prerequisites: PHYS 2123 and MATH 2308.

A discussion of physical optics using Fresnel-Kirchhoff integral equation. Abbe theory of image formation. Coherence, polarization. Maxwell equations as the basis for physical optics.

Text: at the level of Hect and Zajac, *Optics*.

PHYS 3226. Advanced Optical Physics Laboratory
1-3-2. Corequisite: PHYS 3225.

Optional laboratory taken with PHYS 3225. A small number of experiments designed to exemplify the material presented in lecture course.

PHYS 3230. Photographic Principles
2-3-3. Prerequisite: PHYS 2113 or 2123.

Lectures and demonstration (laboratory) period. Relationship of photographic practice and scientific principles: photographic optics, photometry, perspective control, monochrome and color images and processing, image quality.

Text: at the level of Langford, *Basic Photography and Advanced Photography*.

PHYS 3241. Elementary Biophysics I
3-0-3. Prerequisite: PHYS 2123.

Applications of the principles and techniques of the physical sciences to areas of the life sciences.

Text: at the level of Stanford, *Foundations of Biophysics*.

PHYS 3243. Elementary Biophysics II
3-0-3. Prerequisite: PHYS 3241.

A continuation of topics from Physics 3241. Physics of viruses, the central nervous system, and biophysical instrumentation.

Text: at the level of Stanford, *Foundations of Biophysics*.

PHYS 3261. Introduction to Elementary Particle Physics
3-0-3. Prerequisite: PHYS 2123.

Phenomenology of elementary particles. Historical introduction, list of particles, quantum numbers, conservation laws, selection rules, cross sections, decays, strong, electromagnetic, weak interactions: S-matrix, quantum field theory, models.

Text: at the level of Perkins, *Introduction to High Energy Physics*.

PHYS 3263. Computers in Physics
1-6-3. Prerequisites: ICS 1700 or equivalent, PHYS 2123.

Computer solutions of realistic physics problems that use a variety of numerical techniques, including integra-

tion, solution of simultaneous algebraic equations, and solution of differential equations.

PHYS 3264. Computer Analysis of Physics Data
1-6-3. Prerequisite: PHYS 2123.

Computer analysis and acquisition of experimental data from physics experiments, including an introduction to on-line experiment control.

PHYS 3265. Introduction to Acoustics
3-0-3. Prerequisite: PHYS 2112 or 2122.

An introduction to the art and science of acoustics for students of varied backgrounds and interests. The emphasis is on the basic physical mechanisms that underlie all acoustical phenomena.

Text: at the level of Kinsler, *Fundamentals of Acoustics*.

PHYS 3751. Laser Physics
3-0-3. Prerequisite: PHYS 2123.

Principles of laser operations. Types of lasers. Survey lectures on the application of lasers to various fields. Course intended for both physics and nonphysics majors. PHYS 3751 is the same as EE 4751.

Text: at the level of O'Shea, Callen, and Rhodes, *Introduction to Lasers and Their Application*.

PHYS 3801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

PHYS 3900-1-2. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

PHYS 4143. Quantum Mechanics II
5-0-5. Prerequisite: PHYS 3143 or equivalent.

Introduction to perturbation theory, identical particles, spin and semiclassical radiation theory. Applications to atomic physics.

Text: at the level of Park, *Introduction to Quantum Theory*.

PHYS 4146. Special Relativity
5-0-5. Prerequisite: PHYS 3122.

Development of Einstein's special relativity. Four vector notation. Kinematics and dynamics of a particle. Transformation of electromagnetic fields. Transitions of a system, collisions. Successive Lorentz transformations. Spin dynamics.

Text: at the level of Sard, *Relativistic Mechanics*.

PHYS 4206. Interfacing Laboratory I
3-3-4. Prerequisite: PHYS 3211 or equivalent.

Introduction to the interfacing of computers with scientific apparatus. A computer and a variety of interfacing logic are available for the laboratory.

PHYS 4211. Electronic Instruments for Scientific Research
2-3-3. Prerequisite: PHYS 3211 or equivalent.

An intermediate course in electronic instruments and instrumentation as employed in research and general laboratory measurements.

Text: at the level of Littauer, *Pulse Electronics*.

PHYS 4216. Interfacing Laboratory II
1-6-3. Prerequisite: PHYS 4206 or consent of the School.

A continuation of PHYS 4206. Emphasis on individual student design and construction of interfaces for on-line control of experiments.

PHYS 4220. Optical Design
3-3-4. Prerequisite: PHYS 3223 or consent of the School.
Principles of optical design, ray tracing, and third-order aberrations; laboratory stresses optical testing using conventional resolution tests and modulation transfer function.
Text: at the level of Smith, *Optical Engineering*.

PHYS 4221. Optical Fabrication
2-6-4. Prerequisite: PHYS 3223 or consent of the School.
Theory and practice of vacuum deposition of metal and multilayer thin films and of grinding and polishing optical elements.
Text: at the level of Horne, *Optical Production Technology*.

PHYS 4251. Biophysics I
3-0-3. Prerequisites: PHYS 2123, BIOL 2211 or equivalent.
Application of thermodynamics and other physical principles to analysis of energy metabolism and membranes.
Text: at the level of Van Holde, *Physical Biochemistry*.

PHYS 4252. Biophysics II
3-0-3. Prerequisites: PHYS 2123, BIOL 2211 or equivalent.
A study of physical principles governing the conformations and interactions of biological molecules. Emphasis on the properties of nucleic acids and proteins and their interactions.
Text: at the level of Canton and Schimmel, *Biophysical Chemistry*.

PHYS 4254. Biophysics-Biochemistry Laboratory
0-6-2. Prerequisite: PHYS 4251 or consent of the School.
Selected experiments using biophysical and biochemical methods exemplifying studies on macromolecules and the principles of the techniques currently used in molecular biophysics and molecular biology. Offered jointly with BIOL 6640.

PHYS 4261. Atomic Physics
5-0-5. Prerequisite: PHYS 3143 or equivalent.
The structure and spectra of ordinary atoms, mesic atoms, and positronium. Atomic beams techniques. Double resonance and level-crossing spectroscopy. Optical pumping. Properties of leptons.
Text: at the level of Woodgate, *Elementary Atomic Structure*.

PHYS 4262. Solid State Physics
5-0-5. Prerequisites: PHYS 3143; PHYS 3141 or CHEM 2113.
Application of quantum mechanics to molecules and solids. Molecular bonding and spectra of diatomic molecules. Binding forces and bond theory in solids. Applications to solid state devices.
Text: at the level of Ashcroft and Mermin, *Solid State Physics*.

PHYS 4263. Nuclear Physics
5-0-5. Prerequisite: PHYS 3143.

Basic properties of nuclei, interactions of radiation with matter, accelerators, radioactivity, nuclear reactions, nuclear models, elementary particles.
Text: at the level of Evans, *The Atomic Nucleus*.

PHYS 4321-2. Advanced Laboratory I, II
1-6-3 each. Corequisite: PHYS 3143.
May be scheduled in either order. Experiments of classical and contemporary importance selected from various fields of physics. Experiments frequently deal with topics that have not been treated in other courses. Students will be expected to acquire an understanding of significance of experiments through independent study.

PHYS 4755. Introductory Diffraction Studies
3-6-5. Prerequisite: senior standing in physics or consent of the School.
Introductory theory and practice of X-ray and neutron diffraction techniques, mostly powder, e.g., identification, lattice parameters, texture, line breadth, thermal neutron, and crystal orientation.

PHYS 4801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.
Courses in special topics of current interest in physics are presented from time to time.

PHYS 4900-1-2. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

PHYS 6005. Computer Facilities for Graduate Research in Physics
1-6-3.
Introduction to the computational aspects of physics research and the characteristics of the computing systems available.

PHYS 6011. Principles of Nuclear Physics
4-0-4.
Radioactive decay and decay processes, interaction of radiation, statistical considerations in interactions, nuclear structure, stability and models, nuclear reactions and cross sections, properties of neutrons.
Text: at the level of Friedlander, Kennedy, and Miller, *Nuclear and Radio Chemistry*.

PHYS 6121. Theoretical Mechanics I
5-0-5.
Dynamics of particles and rigid bodies, including developments and applications of Lagrange's, Hamilton's and Euler's equations. Potential theory. Gyroscopic motion. Poisson brackets, Hamilton-Jacobi theory.
Text: at the level of Goldstein, *Classical Mechanics*.

PHYS 6122. Electrodynamics
5-0-5.
Discussion of Maxwell's equations, scalar and vector potentials, conservation laws, multipole moments and multipole radiation, dispersion.
Text: at the level of Jackson, *Classical Electrodynamics*.

PHYS 6123. Statistical Mechanics I
5-0-5. Corequisite: PHYS 6121.
Physical applications of probability theory. Classical and quantum statistical mechanics with numerous applications: ideal gas, imperfect gas, liquids, and solids.
Text: at the level of Reif, *Fundamentals of Statistical and Thermal Physics*.

PHYS 6132. Advanced Electricity and Magnetism
5-0-5.
A study of Maxwell's equations, with applications to problems in electrical power systems, communications, signal processing, radiation, and electrical measurements.

PHYS 6141. Quantum Mechanics I
5-0-5. Prerequisite: PHYS 4143 or equivalent.
Nonrelativistic quantum mechanics. Representation of dynamical variables as operators or matrices, theory of angular momentum, perturbation theory, selected topics from radiation and scattering theory.
Text: at the level of Merzbacher, *Quantum Mechanics*.

PHYS 6142. Quantum Mechanics II
5-0-5. Prerequisite: PHYS 6141.
Relativistic quantum mechanics, Dirac theory, the Lorentz group, antiparticles, relativistic Hamiltonians, propagators, Feynman graphs.
Text: at the level of Borken and Drell, *Relativistic Quantum Mechanics*.

PHYS 6143. Quantum Mechanics III
5-0-5. Prerequisite: PHYS 6141.
A problem-solving course that applies principles of quantum mechanics to atomic, molecular, solid-state, and nuclear physics.

PHYS 6232. Solid State Physics I
5-0-5. Prerequisite: PHYS 4143 or equivalent.
Structural, electronic, and vibronic properties of solids; electron gas theory; collective excitations; electromagnetic properties; band structure; transport and thermal properties; semiconductors; defects.

PHYS 6233. Physical Crystallography
3-0-3. Prerequisite: PHYS 4755 or equivalent.
Experimental and analytical aspects of X-ray, neutron and electron diffraction crystallography applied to problems such as physical property mechanisms, defects, and other topics of current physical interest.

PHYS 6263. An Introduction to Collision Theory
3-0-3. Prerequisite: PHYS 4143 or equivalent.
Quantum theory of nonrelativistic elastic and inelastic scattering, rearrangement collisions, central, nonlocal, absorptive interactions, phase shift analysis, variational methods, semiclassical and impulse approximations, transition probabilities.

PHYS 6267. Atomic Collisions
3-0-3.
A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces.

PHYS 6300. Graduate Laboratory
1-6-3.
Students choose a program of several experiments from various fields of physics.

PHYS 7000. Master's Thesis

PHYS 7121. Theoretical Mechanics II
5-0-5. Prerequisite: PHYS 6121.
Advanced topics in classical mechanics, including Hamilton-Jacobi theory, action-angle variables, and can-

onical transformation theory. Introduction to modern theory of dynamical systems.
Text: at the level of Goldstein, *Classical Mechanics*.

PHYS 7122. Electromagnetic Theory
5-0-5. Prerequisite: PHYS 6122.
Discussion of relativistic electrodynamics, radiating systems, multipole expansions, scattering, and diffraction. Exposure to magnetohydrodynamics and plasmas. Use of Lagrangian and Hamiltonian formulations.
Text: at the level of Jackson, *Classical Electrodynamics*.

PHYS 7123. Statistical Mechanics II
5-0-5. Prerequisite: PHYS 6123.
An advanced course in statistical mechanics, including problems of biological significance.

PHYS 7125. Introduction to Relativity
5-0-5. Prerequisites: PHYS 6121, 6122.
Reference frames and transformations, tensor calculus, review of special relativity, electrodynamics, the principle of equivalence, general relativity and gravitation, cosmologies and black holes.

PHYS 7126. Gravity
5-0-5. Prerequisite: PHYS 7125.
Gravitational waves. Experimental tests. Petrov classes. Spinors. Twistors. Simplicial approximations.

PHYS 7141. Quantum Mechanics of Many-particle Systems
5-0-5. Prerequisite: PHYS 6141.
Interacting systems of particles described quantum mechanically using the method of second quantization. Application to Fermi and Bose systems.

PHYS 7143. Group Theory and Quantum Mechanics
5-0-5. Prerequisite: PHYS 6141 or equivalent.
Basic principles of group theory and the representation of groups by matrices. Applications will include atomic and molecular structure.

PHYS 7147. Quantum Field Theory
5-0-5. Prerequisites: PHYS 6141, 6122.
Quantum theory of free fields: scalar, vector, and spinor fields. Conservation laws. S-matrix, Quantum electrodynamics.

PHYS 7999. Preparation for the Comprehensive Examination
Audit only.

PHYS 8001-2-3. Graduate Student Seminar
1-0-1.
Intended mainly for beginning graduate students. There are two series of seminars. Representative research programs in the School are described by advanced graduate students, post-doctorals, and faculty members. The experimental basis of physics is illustrated through accounts of great experiments of importance to contemporary research.

PHYS 8101-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.
Courses in special topics of current interest in physics are presented from time to time.

PHYS 8501-2-3. Special Problems
Credit to be arranged.

PHYS 8511-2-3. Special Problems
Credit to be arranged.

PHYS 8521-2-3. Special Problems in Condensed Matter Physics
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of condensed matter physics.

PHYS 8531-2-3. Special Problems in Acoustics
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of acoustics.

PHYS 8541-2-3. Special Problems in Applied Optics
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of applied optics.

PHYS 8551-2-3. Special Problems in Physics Instrumentation
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the instrumentation associated with experimental research in physics.

PHYS 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate teaching assistantships.

PHYS 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.
For graduate students holding graduate research assistantships.

PHYS 8999. Preparation for Doctoral Dissertation
Audit only. Prerequisite: consent of the School.

PHYS 9000. Doctoral Thesis

School of Psychology

Established in 1959

Professor and Director—Anderson D. Smith; *Regents' Professor Emeritus*—Joseph E. Moore; *Director and Professor Emeritus* —Edward H. Loveland; *Professors*—E. J. Baker, Jack M. Feldmaan, Lawrence R. James, Terry L. Maple, M. Jackson Marr, Stanley A. Mulaik, M. Carr Payne, Jr., Timothy A. Salthouse; *Associate Professors* —Albert N. Badre, Gregory M. Corso, Christopher K. Hertzog, Charles V. Riche, C. Michael York, Craig M. Zimring; *Assistant Professor*—Michael D. Mumford; *Instructors*—Angeline E. Benham, O. Edmund Martin; *Adjunct Professors*—Scarvia B. Anderson, Larry D. Byrd, Randall M. Chambers, Theodore J. Doll, Joanne

Green, Frederick A. King, John R. Maher, Louis D. Silverstein, Barbara J. Winship.

General Information
The School of Psychology serves a dual function in the Institute. First, it offers training in the basic and applied aspects of the science of behavior for the student majoring in architecture, engineering, management, and natural sciences. It also offers programs of study leading to the Bachelor of Science in Applied Psychology and the Master of Science and Doctor of Philosophy in Psychology.

The undergraduate curriculum in psychology stresses fundamentals, providing opportunity for broad training in mathematics, the natural sciences, humanities, social sciences, and management. The large number of elective courses enables the curriculum to fulfill a wide variety of educational and vocational needs. Graduates have been able to engage successfully in postgraduate study in many fields, including business administration, history, industrial management, labor relations, law, medicine, music, psychology, and theology.

The program provides excellent preparation for graduate work in psychology and is especially adaptable to premedical education. Graduates of the program also have been employed successfully in a variety of positions relating to personnel subsystems (including human engineering), personnel research, personnel service, systems development, and the management and administration of business, engineering, and health programs.

Undergraduate Curriculum
The curriculum is technically oriented and stresses quantitative and experimental approaches to the study of behavior. Many graduates of this curriculum have continued their studies in psychology graduate programs, medical and law schools, as well as in other graduate programs leading to degrees in widely diverse fields such as business, education, history, labor relations, marketing, music, and religion. Other graduates have been employed upon graduation in a variety of positions, including general

management, personnel research, personnel services (e.g., personnel training and employment), personnel subsystems (including human factors engineering), engineering psychology research, and systems engineering.

The curriculum lends itself to a special program intended to prepare students to teach behavioral science at the high school level. Through a cooperative arrangement with Georgia State University, interested students may enroll for required education courses at that institution while working toward their bachelor's degree at Georgia Tech. Upon completion of the program, the student will be eligible to apply for a T-4 teaching certificate.

Certificate Program in Psychology
The School of Psychology offers for nonpsychology majors five programs of study leading to certificates in biopsychology, engineering psychology, experimental psychology, industrial/organizational psychology, and social-personality psychology. Each program focuses upon a limited area of psychology that will be of interest and use to students who wish to investigate the psychological complexities inherent in their major fields or to those who simply wish to broaden their educations in a systematic manner. Each certificate requires eighteen hours of prescribed psychology courses.

Curriculum
Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	.....
ICS 1700 Digital Computer Programming	.....	.....	2-3-3
ENGL 1001-2 Analysis of Literature and Language I, II	3-0-3	3-0-3	.....
English Elective	.....	.....	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Modern Languages or Social Sciences Electives	3-0-3	3-0-3	3-0-3

Physical Education (requirements, p. 253)	.....	.....	X-X-3
Free Electives	2-0-2	2-0-2	2-0-2
TOTALS	17-3-18	17-3-18	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
English Electives	3-0-3	3-0-3	3-0-3
MATH 2307 Calculus IV	5-0-5	.....	.....
MATH 2308 Calculus and Linear Algebra	.....	5-0-5	.....
BIOL 1110-1-2 General Biology	3-3-4	3-3-4	3-3-4
PSY 3303-4 General Psychology I, II	.....	3-0-3	3-0-3
PSY 4401 Industrial Psychology	.....	.....	3-0-3
Free Electives	3-0-3	.....	3-0-3
TOTALS	14-3-15	14-3-15	15-3-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
MATH 3710 Introduction to Statistics	5-0-5	.....	.....
PSY 4403 Introduction to Psychological Testing	.....	3-0-3	.....
PSY 4405 Seminar in Organizational Psychology	3-0-3	.....	.....
PSY 4406 Psychology Statistics	.....	.....	2-3-3
PSY 4407 Experimental Psychology I	.....	.....	2-3-3
PSY 4410 Social Psychology	.....	3-0-3	.....
PSY 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Free Electives	3-0-3	3-0-3	6-0-6
TOTALS	15-3-16	13-6-14	16-9-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
PSY 4411 Experimental Psychology II	3-3-4	.....	.....
PSY 4412 Psychology of Learning	.....	3-3-4	.....

PSY 4413 Applied Experimental Psychology	.....	.....	3-3-4
PSY 4814-5 Special Problems	.....	0-3-1	3-3-4
ENGL 3015 Public Speaking	3-0-3	.....	.....
Free Electives	9-0-9	9-0-9	9-0-9
TOTALS	15-3-16	12-6-14	15-6-17

SUBSTITUTIONS

PSY 6602 may be substituted for PSY 4413 with the approval of the School of Psychology. EE 1010 may be substituted for ICS 1700.

ELECTIVES

Modern Languages or Social Sciences

Students have a choice of (1) two quarters of one of the following: American history, political science, philosophy and history of science, or sociology, with the third quarter selected from one of the three remaining areas, or (2) three quarters of one modern foreign language. Students electing modern language courses that total more than nine hours may use the excess hours for free elective credit.

All students are required to pass examinations or courses in the history and constitutions of the United States and Georgia. HIST 1001 or 1002 and POL 1251 or 3200 fulfill this requirement.

Free Electives

These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled. A total of not more than nine hours of electives may be in advanced ROTC. A portion of the free elective hours must be taken from an approved list of engineering and management courses. This list is available in the psychology office.

English Electives

English electives must be from an approved list available from the School of Psychology.

Graduate Curricula

Doctoral and master's candidates share a core curriculum of required courses that includes three proseminars in general psychology, nine additional course hours in psychology to be prescribed by the student's faculty advisory committee with the approval of the director of the School of Psychology, and eighteen hours to be chosen by the student, with the approval of his or her advisory committee, from among courses in psychology and other fields. The School may grant permission to substitute another course for a required course if the student can pass a written examination. Doctoral candidates will complete all requirements for the master's degree, which includes writing a thesis.

Master's programs prepare the student for continuation of graduate work toward the Ph.D. and/or for employment in business, industry, government, or education. Most students require two calendar years to complete the master's degree, which includes writing a thesis.

The doctoral program provides the student with an opportunity for advanced study in general-experimental, industrial-organizational, or engineering psychology. Each of these curricula consists of additional courses and programs of individual study and research beyond the core curriculum, which contribute to a strong background in general experimental psychology, quantitative methodology, and the student's area of specialization. The doctoral program will ordinarily require four years for students who enter immediately after obtaining the bachelor's degree.

Admission to graduate study in psychology with full graduate standing in the School of Psychology requires the equivalent of an undergraduate major in psychology or a related field with courses in general and experimental psychology, psychological statistics, testing and measurement, either industrial psychology or social psychology, and two quarters of calculus. Supplementary education in areas such as biology, chemistry, physics, engineering, foreign languages, and particularly mathematics is also advised. Students who have considerable undergraduate preparation in one or more of these areas may, with the approval of the School of Psychology, exempt some of the required psychology courses. All applicants should submit scores on the Miller Analogies Test and the Graduate Record Examination.

The psychology faculty encourages competent students in subjects other than psychology to apply for admission.

Courses of Instruction

PSY 3300. Psychology and Contemporary Issues in Society
3-0-3.
Contributions of psychology to an appreciation of selected contemporary issues. Topics may vary from quarter to quarter.

PSY 3303. General Psychology I
3-0-3.
An intensive coverage of the methods and findings of contemporary psychology. Includes topics such as psychological development, learning, conditioning, and biological bases of behavior.

PSY 3304. General Psychology II
3-0-3. Prerequisite: PSY 3303.
A continuation of PSY 3303. Topics such as individual differences, perception, personality, and social psychology will be discussed.

PSY 4400. Developmental Psychology
3-0-3. Prerequisite: PSY 3303.
A comprehensive study of human behavior and psychological development from infancy through adolescence. Emphasis is placed on empirical and cross-species contributions.

PSY 4401. Industrial Psychology
3-0-3.
A survey of methods and findings in the scientific study of humans at work. Considered are topics such as selection, training, motivation, accidents, and environmental effects.

PSY 4402. Psychology of Adjustment
3-0-3. Prerequisite: PSY 3303.
Consideration of characteristics and etiology of typical and atypical human behavior. A principal objective is an increased understanding of self and others.

PSY 4403. Introduction to Psychological Testing
3-0-3. Prerequisite: PSY 3304 or 4401.
Consideration of the theoretical and practical issues in psychological measurement, with particular reference to psychological testing.

PSY 4404. Psychology of Advertising
3-0-3. Prerequisites: PSY 3303 or 4401.
An analysis of psychological principles and techniques that serve as a foundation for effective advertising. The scientific study of consumer behavior is emphasized.

PSY 4405. Seminar in Organizational Psychology
3-0-3. Prerequisite: PSY 4401 or 4410.
Study of psychological factors in organizational functioning, including theoretical and research issues.

PSY 4406. Psychological Statistics
2-3-3. Prerequisite: consent of the School.
Application of statistical techniques to the design and analysis of psychological studies.

PSY 4407. Experimental Psychology I
2-3-3. Prerequisite: PSY 3303.
An introduction to psychological measurement and laboratory techniques used in the experimental study of topics such as sensory processes, perception, psychomotor performance and learning.

PSY 4409. Introduction to Engineering Psychology
3-0-3.
Engineering psychology is presented as an integral component in the design and evaluation of man/machine systems. Applied problems and general methodological questions are examined.

PSY 4410. Social Psychology
3-0-3. Prerequisite: PSY 3303.
Consideration of the behavior of the individual in relation to other individuals and groups.

PSY 4411. Experimental Psychology II
3-3-4. Prerequisites: PSY 3304, 4406, 4407 and consent of the School.
Consideration of principles and research methods in the areas of learning and motivation, with special emphasis on classical and operant conditioning of nonhuman animals.

PSY 4412. Psychology of Learning
3-3-4. Prerequisites: PSY 3304, 4406, 4407, and consent of the School.
An empirical and theoretical analysis of human learning, memory, and cognitive processes.

PSY 4413. Applied Experimental Psychology
3-3-4. Prerequisites: PSY 4406, 4412, and consent of the School.
Consideration of the applications of the methods and data of experimental psychology.

PSY 4421. Physiological Psychology
3-0-3. Prerequisites: PSY 3304, BIOL 2211.
Neurophysiological, endocrinological, and biochemical basis of sensory and motor functioning, learning, memory, motivation, and behavior disorders.

PSY 4422. Comparative Psychology
2-2-3. Prerequisites: BIOL 2211, PSY 3304 and consent of the School.
Consideration of principles and research methods of animal psychology and ethology. Literature reviews and reports, field trips and laboratory studies.

PSY 4423. Introduction to Psycholinguistics
3-0-3. Prerequisite: consent of the School.
A critical examination of current psychological research and theory in language development and behavior.

PSY 4424. Introduction to Personality
3-0-3. Prerequisites: PSY 3304 or 4410.
Introduction to and survey of major theories of personality.

PSY 4425. The Psychology of Aging
3-0-3. Prerequisites: senior or graduate standing, PSY 3303 and 3304 or equivalent.

Current research findings and their theoretical and practical implications will be discussed. Interactions between adult age and a variety of psychological processes will be discussed: perception, memory, learning, cognition, personality, psychomotor skill, and psycho-physiological processes.

PSY 4426. Behavioral Pharmacology
3-0-3. Prerequisites: BIOL 2211, PSY 3304, and consent of the instructor.

An introduction to the study of drug-behavior interactions. Among the topics to be treated are the pharmacology of behaviorally active drugs, the influence of drugs on schedule-controlled behavior and stimulus control, the role of drugs as stimuli, and the use of drugs for the analysis of behavior.

PSY 4491-2-3-4. Field Study of Animal Behavior I, II, III, IV
1-6-3 each. Prerequisites: anthropology, biology, or psychology background; demonstrated interest in animal behavior; consent of the instructor.

This course takes place in Kenya, East Africa, and is limited to fifteen qualified students. Lectures by the instructor and resident scientists will provide the in-class portion of the course. Visits to national parks, game preserves, and lengthy in-field observation will introduce the students to the natural habitats of African animals.

PSY 4750. Social Psychology-Sociology Measurement Seminar
3-0-3. Prerequisite: PSY 4410 or equivalent and consent of the School.

Problems, implications, and methodologies relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience. Also taught as SOC 4750.

PSY 4751. Psychology and Environmental Design I
3-3-4. Prerequisite: consent of the School.

Introduction to psychological concepts relevant to environmental design. Survey of selected methods for assessing man-made environment. Taught jointly by psychology and architecture faculty. Cross-listed as ARCH 4751.

PSY 4752. Psychology and Environmental Design II
3-3-4. Prerequisites: PSY 4751 and consent of the School.

Continuation of PSY 4751, with greater emphasis on independent research and development of design solutions to selected problems. Taught jointly by psychology and architecture faculty. Also taught as ARCH 4752.

PSY 4754. Models of Human Information Processing
3-0-3. Prerequisites: PSY 3303, 3304, ICS 1700, or equivalent.

General and unified approaches to psychological and computer modeling of human information processes. Emphasis on neural, sensory memory, semantic, and conceptual processing. Also listed as ICS 4754.

PSY 4755. Sex Roles: Their Development and Cultural Influence
3-0-3. Prerequisite: consent of the School.

Psychological principles, legal facts, and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current, and future. Reading, lectures, discussions, and invited panelists. Also listed as ENGL 4755.

PSY 4800. Special Topics
1-3-2. Prerequisites: PSY 3304, 4407, and consent of the School.

Guided independent study in an area of psychology not represented in the School's course offerings.

PSY 4802-3-4. Special Topics
2-0-2 through 4-0-4 respectively. Prerequisite: consent of the School.

Special topics of current interest.

PSY 4814. Special Topics
0-3-1. Prerequisites: PSY 4406, 4411, and consent of the School.

The student will, under the direction of a staff member, do semi-independent work in literature review and/or experimental design.

PSY 4815. Special Topics
3-3-4. Prerequisite: consent of the School.

Students will work, under the direction of the instructor, on projects adding to their development beyond the scope of existing courses.

PSY 4900-1-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of the School.

Students engage in individual and group projects under the direction of a faculty member.

PSY 4953. Special Problems in Psychological Aspects of Environmental Design
Credit to be arranged. Prerequisites: PSY 4751, 4752, and consent of the School.

Supervised individual study of problems relating to the interaction of environmental design and behavior.

PSY 6601. Advanced Industrial Psychology
3-0-3. Prerequisite: PSY 4401.

A survey of theoretical and pragmatic issues in industrial psychology. Recent developments and experimental findings will be discussed.

PSY 6602. Applied Experimental Psychology
3-0-3. Prerequisite: PSY 3304.

Consideration of the application of the methods and data of experimental psychology to the problems of man and the environment, emphasizing the engineering psychology approach.

PSY 6603. Social Psychology
3-0-3. Prerequisites: six hours of psychology and consent of the School.

A study of principles of social learning, motivation and perception, and of attitudes and beliefs as they relate to behavior of individuals in groups.

PSY 6604. Human Information Processing
3-0-3. Prerequisite: consent of the School.

A study of information processing theories and measurement techniques as applied to psychological problems, emphasizing human perceptual, communication, and learning processes.

PSY 6605. Proseminar in General Psychology I
3-0-3. Prerequisites: graduate standing and consent of the School.

A comprehensive, advanced consideration of general psychology, including topics such as conditioning, learning, memory, and cognitive processes.

PSY 6606. Proseminar in General Psychology II
3-0-3. Prerequisites: graduate standing and consent of the School.

A comprehensive, advanced consideration of general psychology, including topics such as psychological development, perception, and physiological psychology.

PSY 6607. Proseminar in General Psychology III
3-0-3. Prerequisites: PSY 6605, 6606 or equivalent and consent of the School.

A continuation of PSY 6605 and 6606, involving consideration of topics such as personality, individual differences, and social psychology.

PSY 6608. Human Motivation
3-0-3. Prerequisites: graduate standing, PSY 6605, and consent of the School.

Examines theoretical and pragmatic issues in the description and prediction of motivated behavior. Includes measurement problems, implications, and applications in a range of settings.

PSY 6609. Social Psychology of Organizations
3-0-3. Prerequisites: PSY 4410 or equivalent and consent of the School.

Selected topics from social psychology that are of particular significance to an understanding of individual behavior in an organizational context. Supervised readings and discussion.

PSY 6610. Psychoacoustics
3-0-3. Prerequisites: PSY 3304 or equivalent and consent of the School.

A comprehensive coverage of physiological and psychological acoustics, including analyses of auditory and extra-auditory response mechanisms and evaluation of research and theories in hearing.

PSY 6621-2. Foundations of Psychology I, II
3-0-3 each. Prerequisites: graduate standing and consent of the School.

A sequence involving historical and current points of view in psychology, emphasizing issues important for psychological theory.

PSY 6623-4. Design of Psychological Experiments I, II
2-3-3 each. Prerequisites: graduate standing, MATH 3710, PSY 4406 or equivalent and consent of the School.

A two-quarter sequence on the planning and implementation of research based on linear models, with reference to statistical consideration in data reduction and analysis.

PSY 6625. Experimental Methods in Psychology
2-3-3. Prerequisites: graduate standing, PSY 6605, 6606, 6623 or equivalent and consent of the School.

Measuring the dependent variable in psychological experiments. Discussion is supplemented by practice in designing, conducting, and reporting experiments.

PSY 6626. Response Evaluation
3-0-3. Prerequisites: graduate standing, PSY 4406 or equivalent, and consent of the School.

Intensive consideration of theoretical and pragmatic problems in the description and evaluation of human responses in areas such as task analysis and performance measurement.

PSY 6627. Human Learning
3-0-3. Prerequisites: graduate standing, PSY 3303 or equivalent, and consent of the School.

A comprehensive consideration of principles, problems, methods, and experimental data in the study of human learning, including discussion of applications of theory and experimental findings.

PSY 6629. Psychomotor Skill Learning and Performance
3-0-3. Prerequisites: PSY 4406, 6605, 6606, or equivalent.

Human capabilities and limitations for learning and performing psychomotor skills are studied. Emphasis is on performance measurement and assessment of skill proficiency, prediction, and control.

PSY 6630. Psychometric Theory
3-0-3. Prerequisites: PSY 4403, 6624, or equivalent.

Preparation of students in statistical theory and techniques relevant to becoming professionally involved in construction, analysis, and evaluation of psychological and personnel tests.

PSY 6631. Personality and Social Development
3-0-3. Prerequisite: PSY 6607 or equivalent.

The developmental aspects of personality and socialization in children are examined. Particular attention will be given to empirically derived data, assessment techniques, and theoretical explanations.

PSY 6632. Perceptual Development
3-0-3. Prerequisite: PSY 6606 or equivalent.

Perceptual capabilities and experience are examined as they change across the life span. Special attention will be given to early development (infancy and childhood).

PSY 6680. Multivariate Analysis
5-0-5. Prerequisite: PSY 6624 or equivalent and consent of the School.

Introduction to multivariate analysis in psychology with special emphasis on factor analysis.

PSY 6799. Quasiexperimental Design
3-0-3. Prerequisite: ISYE 6400 or 6401, or PSY 6623 and 6624.

Design, application, statistical analysis, and critical evaluation of quasi-experiments (i.e., extension of experimental design concepts into field settings that preclude ideal, randomized experiments).

PSY 7000. Master's Thesis

PSY 7010. Seminar in Industrial Psychology
3-0-3. Prerequisites: PSY 6601, 6607, and consent of the School.

Critical and comprehensive examination of current problems in a selected area of industrial psychology. The area to be covered may vary from year to year.

PSY 7011. Seminar in Experimental Psychology
3-0-3. Prerequisites: PSY 6607, 6625, and consent of the School.

Critical examination of current problems in a selected area of general experimental psychology. Area to be discussed may vary each time the course is offered.

PSY 7012. Seminar in Engineering Psychology
3-0-3. Prerequisites: PSY 6602, 6607, and consent of the School.

Critical examination of current problems in a selected area of engineering psychology. The area to be discussed may vary each time the course is offered.

PSY 7020. Advanced Learning
3-0-3. Prerequisites: graduate standing, PSY 6605 or equivalent, and consent of the School.

An advanced and systematic examination of selected topics dealing with the experimental psychology of learning and memory. Theoretical approaches to learning, transfer, and retention will be discussed.

PSY 7021. Sensation and Perception
4-0-4. Prerequisites: PSY 6606 or equivalent and consent of the School.

An examination of human interpretation of physical stimulation. The student studies in some detail the nature of perceptual processes, including human sensory processes.

PSY 7022. Vision
3-0-3. Prerequisite: PSY 6606 or equivalent.

An advanced examination of the visual processes and the fundamental role they play in human behavior. Emphasis is placed upon objectively obtained data.

PSY 7023. Operant Conditioning
4-0-4. Prerequisite: PSY 6605 or equivalent.

Intensive treatment of methods, data, and problem areas of operant conditioning. Among the topics covered are response differentiation, schedules of reinforcement, and stimulus control.

PSY 7024. Primate Behavior
3-0-3. Prerequisites: graduate standing and consent of the School.

A survey of research relating to primate behavior. A content course in which the major findings and theories of primate behavior will be considered; students will also discuss the methods employed in primate research, and observe selected species at the Yerkes Primate Research Center and Atlanta Zoological Park.

PSY 7050. Professional Problems
2-0-2. Prerequisite: graduate standing and consent of the School.

Introduces the student to professional problems that he or she may face as a psychologist, including teaching, professional practice, and research. Ethical issues will be examined.

PSY 7051. Teaching Practicum
1-3-2. Prerequisite: PSY 7050.

Supervised college teaching for advanced graduate students in psychology. Discussion of teaching techniques, course and curriculum design in psychology, and student evaluation is included in the course. Students will prepare and present lectures on selected topics in psychology

courses. Direct observation and television taping will be used as a basis for class discussions.

PSY 7750. Seminar on Psychology and Management
3-0-3. Prerequisites: PSY 6601, 6609, MGT 6150 or 61105, and consent of the School.

Preparation and discussion of papers on management problems involving psychological complexities. Jointly taught by members of the psychology and industrial management faculties.

PSY 8504. Special Problems in Industrial Psychology
Credit to be arranged. Prerequisites: PSY 6601, 6602, or 6603.

Students will be expected to plan and execute a research problem involving investigation of some psychological aspect of management problems.

PSY 8505. Special Problems in Experimental Psychology
Credit to be arranged. Prerequisite: consent of the School.

Students conduct research under direction of a faculty member on problems in the general area of experimental psychology.

PSY 8506. Special Problems in Engineering Psychology
Credit to be arranged. Prerequisites: PSY 6602 or equivalent and consent of the School.

Students conduct research under direction of a faculty member on problems in the area of engineering psychology.

PSY 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

PSY 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate research assistantships.

PSY 9000. Doctoral Thesis

School of Social Sciences

Established in 1948

Director—Daniel S. Papp; *Fuller E. Callaway Chair of History of Science and Technology*—Melvin Kranzberg; *Professors*—Ronald H. Bayor, Patrick Kelly, Robert C. McMath, Jr., Daniel S. Papp, Frederick A. Rossini; *Associate Professors*—James E. Brittain, Stanley R. Carpenter, Lawrence Foster, August W. Giebelhaus, John J. Havick, John R. McIntyre, David H. Ray, Germaine M. Reed, J. David Roessner, Sandra W. Thornton, Dorothy C. Yancy; *Assistant Professors*—Victoria Durant-

Gonzalez, John Garver, Jon J. Johnston, Gregory H. Nobles.

General Information
The School of Social Sciences offers undergraduate course work in history, philosophy of science and technology, political science, and sociology as well as graduate courses leading to the Master of Science in Technology and Science Policy. Through this curriculum, the students gain an understanding of the complex issues that confront contemporary society. In addition, by comprehending certain aspects of societal and human relationships, students develop skills that enhance their professional expertise.

Certificate Programs in the Social Sciences
Seven certificate programs enable students to concentrate course work in areas of their particular interest. Each program provides for the systematic acquisition of ideas and opinions that enrich the students' understanding of the social dimensions and cultural roots of their professional majors. To aid students planning graduate studies in law, medicine, or business, the certificate program also strengthens the students' backgrounds by allowing them to gain competence in areas additional to their majors.

Four of the seven certificate programs are in the traditional disciplines of history, philosophy, political science, and sociology. The remaining three programs cut across discipline lines to provide a foundation in international affairs, the interaction of science, technology and society, and urban studies.

Students interested in planning a certificate program in one of these areas should contact the School of Social Sciences for further information. A faculty adviser assists each student in planning a program of study to meet his or her needs and interests. The social sciences office can provide detailed information concerning these programs.

United States and Georgia History and Constitution Requirements
The state of Georgia requires all students to take courses or pass examinations in the history and constitutions of the United States and Georgia. POL 1251 or 3200 and HIST 1001 or 1002 fulfill these requirements.

The School administers examinations for both requirements each quarter (only to first quarter seniors). Students who do not take the exams or who do not pass the exams must take the appropriate course(s) prior to graduation.

Graduate Program in Technology and Science Policy
The M.S. program in the rapidly expanding field of technology and science policy trains, in one to two years of study, professionals with technical and scientific backgrounds to identify and analyze policy issues emerging from technological and scientific development in contemporary societies. Graduates may anticipate professional employment by agencies involved in preparing technology assessments and environmental impact statements, formulating corporate responses to governmental policies affecting energy and the environment, evaluating the effects of governmental and corporate policies on technology transfer and related issues.

The program includes an intensive eighteen-hour multidisciplinary core involving theory and both quantitative and qualitative methodology. It also requires an elective concentration of at least fifteen hours, designed for the individual student's career needs, and a thesis. When possible, the thesis requirement will place the student in an internship environment similar to anticipated professional employment.

The team-taught core curriculum and the small number of students per faculty member will bring the student into early and intensive contact with faculty members. The program's flexibility in elective and thesis requirements allows the student an opportunity to arrange a custom-designed program.

Students applying for admission to the professional master's degree program must have earned a bachelor's degree from an accredited institution. Students should have a bachelor's degree or strong undergraduate concentration in engineering or science, with experience in statistics. However, well-prepared students with other majors may also apply.

Courses of Instruction

HISTORY

HIST 1001. History of the United States to 1865
3-0-3.
A survey of the social, political, and economic history of the United States through the Civil War, with emphasis on selected topics. Gives exemption from United States and Georgia history examination.

HIST 1002. History of the United States from 1865 to the Present
3-0-3.
A survey of the social, political, and economic history of the United States from the Civil War to the present, with emphasis on selected topics. Gives exemption from United States and Georgia history examination.

HIST 1028. Introduction to the History of Science and Technology
3-0-3.
An introductory survey of the development of science and technology from antiquity to the present. Emphasis placed on sociocultural context and scientific and technological revolutions.

HIST 3001. Origins of Modern Times: Western Civilization, 1500 to 1789
3-0-3.
An examination of the social, economic, and political currents of early modern Europe. Among the themes covered are social developments and religious conflict, the emergence of a modern world economy, state centralization, and the advent of the scientific revolution.

HIST 3003. Nineteenth-century Europe
3-0-3.
This course traces the development of political ideologies, industrialization, labor activism, modern nation-state building, and imperialism from the French Revolution to World War I.

HIST 3004. World Problems since 1914
3-0-3.
Various twentieth-century European themes to be examined in this course include the crisis of global war, communism, fascism, and the movement for European integration.

HIST 3005. Classical Greek History, c. 3000 to 323 B.C.
3-0-3.
The political, economic, cultural, and religious development of Classical Greek society, including Minoan and Mycenaean civilizations, Periclean Athens, and the era of Alexander the Great.

HIST 3006. Roman History, c. 31 B.C. to 400 A.D.
3-0-3.
The political, economic, cultural, and religious development of Imperial Rome, including the accomplishments of Roman civilization, early Christianity, collapse of the Western empire, and formation of the Byzantine empire.

HIST 3007. Early Middle Ages, 350 to 1050
3-0-3.
The political, economic, and cultural development of Western Europe, including the demise of the Roman Empire, the barbarian kingdoms, the explosion of Islam, monasticism, and the empire of Charlemagne.

HIST 3008. High Middle Ages, 1050 to 1400
3-0-3.
The political, economic, and cultural development of Western Europe, including the blossoming of medieval culture, the struggle between church and state, European monarchies, and the Crusades.

HIST 3012. History of Georgia
3-0-3. Prerequisite: any one of HIST 1001, 1002, or consent of the School.
The problems that have confronted Georgia are examined in their historical setting. Relationship to the national scene gives perspective to the state's place in the nation.

HIST 3013. United States Colonial History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Settlement and growth of the English colonies in North America, with emphasis on the foundation of American political and economic institutions.

HIST 3015. Survey of Sciences in the Sixteenth and Seventeenth Centuries
3-0-3.
An interpretative study of the scientific revolution including, the social, economic, and cultural context and origins of science in America.

HIST 3016. Survey of Sciences in the Eighteenth and Nineteenth Centuries
3-0-3.
The evolution of science and scientific institutions in Europe and the United States, including rise of industrial research.

HIST 3017. History of the Old South to 1865
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
A study of social, political, and economic developments in the South from the colonial period through the Civil War.

HIST 3018. History of the New South since 1865
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
An examination of social, political, and economic developments from the Reconstruction period to the present.

HIST 3020. American Diplomatic History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
American diplomatic history since the Revolutionary War, with emphasis on developments in the twentieth century.

HIST 3022. Afro-American History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Historical analysis of the black American from the ancient African beginnings to the present.

HIST 3024. The American Civil War
3-0-3. Prerequisite: HIST 1001, 1002, consent of the School.
A survey with major emphasis on the military history of the war. Individual research is stressed.

HIST 3025. American Economic History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Special attention given to the rise of technology, our industrial system, the westward movement, development of our banking system, and government regulation of industry.

HIST 3026. History of American Business
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Focuses on the development of business institutions from the colonial period up to the present. Themes stressed include the role of the entrepreneur, the emergence of "big business," the evolution of new business structures, government-business relations, and business and society.

HIST 3027. History of Energy
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
The historical development of major energy sources, history of alternative energy technologies, and evolution of public policy in energy-related areas.

HIST 3028. United States Social and Intellectual History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Studies in the social and intellectual traditions of the United States, with emphasis on the more recent period. Assigned readings.

HIST 3030. Technology and Economic Change
3-0-3.
Growth of technology in the modern world in its relationship to economic and social change.

HIST 3040. Recent Latin American History
3-0-3.
An examination of the roots of contemporary Latin American issues such as underdevelopment and modernization; nationalism and interregional integration; and social structures and institutions. Consists of a general overview and case studies.

HIST 3047-8-9. Technology in Western Civilization I, II, III
3-0-3 each.

The development of technology from the beginnings of man to the present, with emphasis upon interrelations between technology and society.

HIST 3786. America's Immigrant and Ethnic Experience
3-0-3. Prerequisites: HIST 1001, 1002, or consent of the School.
The history of immigrant/ethnic groups such as English, Blacks, Irish, Germans, Asians, Southern and Eastern Europeans, Hispanics; exploring Old World reasons for emigrating, New World reactions, assimilation, bigotry, restrictive immigration policies, the Second World War relocation camp experience, alienation, the American Dream fulfilled.

HIST 4008. History of Technology in the United States
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
A study of technology in America from the colonial period to the present, including industrial and engineering history.

HIST 4016. History of Electrical Sciences and Technology
3-0-3.
The origins and evolution of electrical science, technology, and engineering. Emphasis placed on impact of major innovations in power, communications, and electronics.

HIST 4025. The United States since 1917
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Social, political, economic, and diplomatic history of the United States in the middle of the twentieth century is examined as to causes, results, and movements.

HIST 4050. Twentieth Century Black History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
The inequities and achievements of the period are dealt with through an analysis of selected topics.

HIST 4075. The City in American History
3-0-3. Prerequisite: HIST 1001, 1002, or consent of the School.
Selected topics concerning the social, economic, and political history of American cities, with emphasis on the role of technology in urban development.

HIST 4875-6-7. Special Topics in History
3-0-3.

HIST 4925-6-7-8-9. Special Problems in History
Credit to be arranged.

PHILOSOPHY OF SCIENCE AND TECHNOLOGY

PST 1126. Introduction to Philosophical Analysis
3-0-3.
An introduction to the nature of philosophy through critical study of selected works. The relation of philosophy to science, religion, and society will be emphasized.

PST 1127. Science, Technology, and Human Values
3-0-3.

An examination of the ways engineering technology shapes and is shaped by societal values. Also considers the appropriate and intermediate technology movements.

PST 3102. History of Ancient Philosophy
3-0-3.
A study of the development of philosophy from the early pre-Socratics' scientific writings to Christian thought. The works of Plato and Aristotle are stressed.

PST 3103. History of Modern Philosophy
3-0-3.
The development of Western thought from Bacon to Kant, with emphasis on the philosophical dimensions of the rise of modern science.

PST 3104. Contemporary Philosophy
3-0-3.
A study of the diverse movements in philosophy from Hegel to Russell, with emphasis on the philosophic response to the development of modern scientific inquiry.

PST 3105. Types of Ethical Theory
3-0-3.
Critical examination of ethical theories, consideration of theoretical problems of ethics, nature and presuppositions of ethical judgments, justification and ethical standards.

PST 3107. Comparative Religions
3-0-3.
Introduction to the development of the most important concepts in modern religious systems. Emphasis will be placed on the contributions of philosophical analysis and theological debate.

PST 3113. Symbolic Logic
3-0-3.
An introduction to the symbolic analysis of logical argument. Includes propositional calculus, truth tables, truth trees, and methods of deduction.

PST 4110. Theories of Knowledge
3-0-3. Prerequisite: PST 1126 or 1127 or consent of the instructor.
Critical examination of perception, verification, a priori a posteriori knowledge, meaning and criteria of truth, presuppositions and cognitive significance of scientific and philosophical propositions.

PST 4115. Philosophy of Science
3-0-3. Prerequisite: PST 1126 or 1127 or consent of the instructor.
Examination of selected problems such as causality, inductions, scientific explanation, development of scientific knowledge, social and philosophical import of scientific theories.

PST 4757. Technology Assessment
3-0-3. Prerequisite: junior standing.
Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended, or modified. Considers concepts, organization, and uses of various specific assessment methods.

PST 4875-6-7. Special Topics in the Philosophy of Science and Technology
3-0-3. Topics to be selected.

PST 4944-5-6-7-8. Selected Problems in the History of Science
Credit to be arranged.

PST 4949. Special Problems
Credit to be arranged.

PST 8549. Special Problems
Credit to be arranged.

POLITICAL SCIENCE

POL 1251. Government of the United States
3-0-3.
Study of structure and function of governments of United States and Georgia. Gives exemption from United States and Georgia Constitution examination.

POL 3200. American Constitutional Problems
3-0-3.
Study of structure and function of United States and Georgia government, taught largely through medium of constitutional law. Gives exemption from United States and Georgia Constitution examination.

POL 3203. National Defense Policy
3-0-3. Prerequisite: POL 1251 or consent of the School.
Analysis of recent and current United States defense policy, including an examination of defense decision making.

POL 3204. United States Military Policies
3-0-3. Prerequisite: POL 1251 or consent of the School.
Examination of the armed forces' relationship to society with particular emphasis on the development of the military-industrial complex.

POL 3205. American Foreign Policy
3-0-3. Prerequisite: POL 1251 or consent of the School.
Study of formulation and implementation of United States foreign policy, stressing economic, political, and strategic factors.

POL 3210. National Legislative Processes
3-0-3.
Empirical and systematic analysis of national legislative branch, with attention to relationships among executive branch, interest groups, and Congress.

POL 3211. The American Presidency
3-0-3. Prerequisite: POL 1251 or consent of the School.
Source, nature, and use of presidential power, the roles of the President. Recent historical examples emphasized.

POL 3215. Public Opinion
3-0-3. Prerequisite: POL 1251 or consent of the School.
Public opinion polling techniques, including sampling, questionnaire construction, and interpretation. Analysis of actual opinion data collected on a national basis.

POL 3216. American Political Parties
3-0-3. Prerequisite: POL 1251 or consent of the School.
Study of political party developments and their role in the electoral process.

POL 3217. State and Local Government
3-0-3. Prerequisite: POL 1251 or consent of the School.
Analysis of structure and function of state, county, and municipal government.

POL 3220. Urban Government and Political Problems
3-0-3. Prerequisite: POL 1251 or consent of the School.
An examination of political institutions and processes in the urban setting, including metropolitan government and intergovernmental relations.

POL 3221. Urban Political Problems
3-0-3. Prerequisite: POL 1251 or consent of the School.
A consideration of urban political behavior, including brokerage politics, politics in suburbia, and community power structures.

POL 3250. Public Administration and Public Policy
3-0-3. Prerequisite: POL 1251 or consent of the School.
Study of decision-making and organization theory, bureaucratic policymaking, intergovernmental relations, taxing and spending policy.

POL 3265. Latin American Governments and Politics
3-0-3.
A survey of governmental and political processes in Latin American countries.

POL 3266. The Developing Nations
3-0-3.
A study of selected underdeveloped nations, including economic and political development.

POL 3270. Western European Governments and Politics
3-0-3.
Comparative analysis of governmental and political processes in the nations of Western Europe.

POL 3275. Foundations of International Relations
3-0-3. Prerequisite: POL 1251 or consent of the School.
An analysis of the theory and structure of the international system and their application to the contemporary international affairs.

POL 3280. Communist Political Systems
3-0-3.
An analysis of governmental and political processes in the Communist governments.

POL 3281. Soviet Foreign Policy
3-0-3.
A study of the formulation and conduct of Soviet foreign policy. Consideration of ideological, geopolitical influences, development of relations with the Western world and the Third World.

POL 4205. Mass Communications and the Political Process
3-0-3. Prerequisite: POL 1251.
Examination of communications policies, the political process that shapes these policies, and the role of the mass media in the political process.

POL 4210. Science, Technology, and Public Policy
3-0-3. Prerequisite: POL 1251 or consent of the School.
Examination of relationship between science and government, including the effect of each area on the other in decision-making processes.

POL 4211. Science, Technology, and World Politics
3-0-3.
An analysis of impact of science-technology on the international system: role of science and technology in foreign policy process.

POL 4212. Government Policy and Technological Innovation
3-0-3. Prerequisite: POL 1251 or equivalent, or consent of the instructor.
Explores the relationship between government policy and the development and use of new technology in the private economy, and between technological innovation and economic growth.

POL 4250. Policy Analysis and Evaluation
3-0-3.
Study of the policy adviser in and out of government, social indicators and social accounting, evaluation of public policy, evaluation research techniques.

POL 4755. Sex Roles: Their Development and Cultural Influence
3-0-3.
Psychological principles, legal facts, and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current, and future. Also listed as ENGL 4755 and PSY 4755.

POL 4875-6-7. Special Topics in Political Science
3-0-3.

POL 4950, 4953-4-5-6. Special Problems in Political Science
Credit to be arranged.

POL 4951. Georgia Internship Program
Credit to be arranged (15 hours maximum).
Work-study program assigning student to project in state or local government. Student prepares research paper under jurisdiction of faculty member.

POL 4952. Legislative Intern Program
Credit to be arranged.
Service learning program combining an academic study of the legislative process with an internship at the Georgia legislature in winter quarter. Interns selected competitively each year.

POL 6952. Legislative Intern Program
Credit to be arranged.
Service learning program combining an academic study of the legislative process with an internship at the Georgia legislature in winter quarter. Interns selected competitively each year.

POL 8574. Special Problems in Political Science
Credit to be arranged.
Topics to be selected.

SOCIOLOGY

SOC 1376. Introduction to the Principles of Sociology
3-0-3.
A study of basic social relations, including social structure and functions, analysis of social processes, the foundations of personality, and analysis of social organization.

SOC 1377. Social Institutions
3-0-3.
An analysis of the structure and functions of social institutions, including familial, educational, religious,

economic, and political. A study of institutional change and social disorganization.

SOC 1378. Social Problems in a Changing Society
3-0-3.

Some major social problems of modern society including crime, poverty, pollution, war, racism, and urban unrest.

SOC 1379. Introduction to Demography
3-0-3.

Factors affecting population problems, population growth, fertility, mortality, migration, distribution, and composition.

SOC 3306. Urbanization
3-0-3. Prerequisite: SOC 1376.

Growth of metropolitan communities, differentiation of functions, urban complexity, ecological areas, the city as a way of life, measures and trends in the process of urbanization.

SOC 3308. Statistics for Planning
3-0-3.

Statistical principles for analysis of economic, social, and population data, sampling, measures of central tendencies, normal curve, testing of findings, correlation and arriving at conclusions.

SOC 3335. Social Problems of Industry
3-0-3. Prerequisite: SOC 1376 or consent of the School.

A study of the nature of human relations in large-scale organizations, significance of authority, roles, communication, status and group norms in the work situation.

SOC 3338. Individual and Society
3-0-3. Prerequisite: SOC 1376 or consent of the School.

A study of the nature of interpersonal relations in small groups and in large social settings, a consideration of the problem of alienations and anomie.

SOC 3339. Urban Sociology
3-0-3. Prerequisite: SOC 1376.

Introduces student to basic concepts of sociology as applied to urban phenomena, nature of urbanism, and consequences for social relations and human personality.

SOC 3340. Urban Ecology and Demography
3-0-3. Prerequisite: SOC 1376.

Involves application of ecological perspective to the study of urban phenomena, human spatial distribution theories of city location and patterns of city growth.

SOC 3501. Sociology of Science
3-0-3. Prerequisite: SOC 1376 or SOC 1377 or consent of the instructor.

Introduction to science and technology as a social and cultural phenomenon. Topics include the cultural contexts of the roles played by scientists and engineers in contemporary society and the institutional tensions between science and government.

SOC 3875-6-7. Special Topics in Anthropology
3-0-3.

SOC 4306. Technology and Society
3-0-3. Normally taken by seniors or graduate students.

Analysis of social conditions that promote or retard technological activity. Particular emphasis on the social

role of the scientific and engineering professions in that development.

SOC 4311. The Sociology of the Third World
3-0-3.

Principal focus on Third World countries as societies in development and thus affected by planning, technological innovation, and policy activity. Discussion of development issues at both the national and family levels.

SOC 4756. Technological Forecasting
3-0-3.

Emphasizes forecasting future trends and specific developments in areas of technology. Develops methodologies for identifying future functional capabilities and needs. Case histories in technological forecasting are utilized.

SOC 4875-6-7. Special Topics in Sociology
3-0-3. Topics to be selected.

SOC 4999. Special Problems in Sociology
Credit to be arranged.

TECHNOLOGY AND SCIENCE POLICY

TASP 6001. Technology, Science, and Society
3-0-3.

An intensive survey of the key issues in the relationship between technology and society. Technology and science are analyzed as knowledge systems and social institutions through an examination of major theoretical perspectives and cases.

TASP 6002. Policy Process and Analysis
3-0-3.

The major techniques and analytical approaches to the policy-making process at various levels of government and in the private sector.

TASP 6003. Selected Socio-technical Policy Issues
3-0-3.

A comprehensive study of current socio-technical policy issues, with emphasis on the writing of reports simulating those typically encountered in the field.

TASP 6011. Logic of Inquiry
3-0-3.

The first course in the methodology core sequence familiarizes the student with basic conceptual issues and techniques, and prepares one to design and evaluate research programs.

TASP 6012. Research Design and Data Analysis I
3-0-3. Prerequisite: any undergraduate course in statistics.

Focuses on communication of specific strategies and techniques for designing policy-relevant projects, data gathering, and statistical analysis.

TASP 6013. Data Analysis II and Forecasting
3-0-3. Prerequisite: TASP 6012.

A continuation of data analysis, considering the general linear model and topics in multivariate analysis. Emphasis on the techniques of social forecasting.

TASP 7000. Master's Thesis
A thesis meeting the Institute's requirements. Required.

TASP 8121-2-3-4-5. Special Topics
1-0-1 through 5-0-5 respectively.

TASP 8545-6-7-8-9. Special Problems
Credit to be arranged.

TASP 8997. Teaching Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

For graduate students holding graduate teaching assistantships.

TASP 8998. Research Assistantship
Credit to be arranged. Audit basis only. Prerequisite: consent of the School.

. For graduate students holding graduate research assistantships.

Student Rules and Regulations

Originally approved by the faculty May 24, 1949. Revised printings: 1952, 1957, 1960, 1965, 1968, 1971, 1973. Revised annually since 1973.

I. Purpose

These regulations are intended to set forth the requirements of the faculty to the end that a large student body may live and work together harmoniously with a minimum of friction and misunderstanding. Each student is expected to be a law-abiding citizen and to obey the laws of the city of Atlanta, Fulton County, the state of Georgia, and the United States.

II. Responsibility for Notices and Change of Address

A. Notices
All students will be required to have a box in the post office of the Georgia Institute of Technology, which will be their official address, and they are expected to check this box each school day. Students are also expected to be aware of the contents of the general notices that appear in the *Technique*.

B. Change of Address
Students are responsible for reporting changes of residential address, within one week, to the Office of the Registrar.

C. Unclaimed Mail
Students are responsible for returning to the front window of the Post Office all mail in their post office boxes that is unclaimed after three days.

III. Attendance

A. General
1. Each quarter a course listing is published showing the time period for each class. Classes begin five minutes after the published starting time.
2. If an instructor should be late in meeting the class, the students shall wait twenty minutes after the published starting time. If the instructor has not arrived by that time, the students may leave unless specifically notified to await the instructor's arrival.

B. Class Attendance
1. There are no formal institutional regulations regarding class attendance at the Georgia Institute of Technology. The resources of the Institute are provided for the intellectual growth and development of the students who attend. A schedule of courses is provided for the students and faculty to facilitate an orderly arrangement of the program of instruction. The fact that classes are scheduled is evidence that attendance is important; students should, therefore, maintain regular attendance if they are to attain maximum success in the pursuit of their studies.
2. All students are responsible for obtaining an understanding of each instructor's policy regarding absences; all students are expected to attend announced quizzes, laboratory periods, and final examinations. Although it is recognized that occasionally it may be necessary for students to be absent from scheduled classes or laboratories for personal reasons, students are responsible for all material covered in their absences, and they are responsible for the academic consequences of their absences. Work missed may be made up if the reasons for absences are acceptable to the instructors.
3. Students who are absent because of participation in approved Institute activities (such as field trips and athletic events) will be permitted to make up the work missed during their absences. Approval of such activities will be granted by the Student Academic and Financial Affairs Committee of the Academic Senate, and statements of the approved absence may be obtained from the Office of the Registrar.

IV. Grades and Scholastic Average

A. Grades
1. The letter grades for completed courses used in the calculation of scholastic average are the following:
A—excellent (four quality points)
B—good (three quality points)
C—satisfactory (two quality points)
D—passing (one quality point)
F—failure, must be repeated if in a required course (no quality points)
2. The following grades will be used in the cases indicated and will not be included in the calculation of scholastic average:
S—passing of a course taken under pass/fail or completion of a course in which no letter grade may be assigned;
U—failure of a course taken under pass/fail or unsatisfactory performance in a course for which no letter grade may be assigned;
V—assigned when the course has been audited; no credit given; and implies no academic achievement on the part of the student.
3. The following grades will be used in the cases indicated:
I—incomplete. Assigned when a student is incomplete in some part of the course for reasons deemed satisfactory by the instructor or is absent from the final examination for reasons deemed satisfactory by the instructor. If the student's record is so poor as to preclude his/her passing, the instructor shall assign the grade of F or U. (Note: Registering and repeating a course in which an I grade has been assigned will not remove the outstanding I grade.)
W—out before the end of the fifth week. This symbol indicates that a student was permitted to withdraw without penalty. Withdrawals without penalty will not be permitted after the fifth week except in cases of hardship as determined by the registrar. Ordinarily, students who withdraw from school and receive all grades of W will not be permitted to re-enroll the next succeeding quarter.
4. Final grades are reported to the registrar at the end of each term.

5. If a final course grade is believed to be in error, the student should contact the professor as soon as possible. In general, no change of grade will be made after the end of the student's next quarter in residence.

B. Scholastic Average

The scholastic average is calculated as the ratio of the total number of quality points earned to the total number of quarter credit hours in which a final letter grade has been assigned.

V. Scholastic Regulations

A. Classification of Students

1. Undergraduate students with the exception of nondegree seeking students shall be classified at the end of each quarter by the Office of the Registrar on the basis of the total number of quarter credit hours for which they have credit in accordance with the following schedule:

Freshman	0—44	credit hours
Sophomore	45—89	credit hours
Junior	90—134	credit hours
Senior	135—	graduation

Students who have completed all requirements for a particular classification as defined by their major department may petition for reclassification through their major department.

2. Students scheduled for twelve credit hours or more are classified as full-time students.

B. Eligibility for Class Rings

A student may purchase a class ring any time after receiving credit for 106 quarter credit hours.

C. Scholastic Standing

1. The minimum satisfactory scholastic average is 1.7 for freshmen, 1.9 for sophomores, 2.0 for juniors and seniors, and 2.7 for graduate students.

2. Good academic standing

a. Students not on academic probation are in good academic standing.

b. Undergraduate students in good academic standing may schedule up to twenty-three credit hours with the approval of their school.

c. Graduate students in good academic standing may schedule up to twenty-one credit hours with the approval of their school.

3. Academic warning

a. A student who has an overall scholastic average below the minimum satisfactory scholarship requirement, or whose scholastic average for work taken during any quarter is below this requirement, shall be placed on academic warning.

b. An undergraduate student on academic warning shall be limited to a maximum schedule load of sixteen credit hours.

4. Academic probation

a. A student on academic warning whose scholastic average is below the minimum satisfactory scholarship requirement for any quarter shall be placed on academic probation. Also see 6.b and 6.c.

b. An undergraduate student on academic probation shall be limited to a maximum load of fourteen credit hours.

5. Dean's List

The Institute encourages excellence in scholarship and gives official recognition to undergraduate students whose work is superior by publishing the Dean's List at the end of each academic quarter. The Dean's List includes all undergraduates who, during the preceding quarter, have an academic average of 3.0 or higher, carried a load of at least twelve hours of course work on a credit basis, and are not on academic warning or probation or subject to any disciplinary action.

6. Dismissal for unsatisfactory scholarship

a. The Institute may drop from the rolls at any time a student whose record in scholarship is unsatisfactory.

b. An undergraduate student whose scholastic average for any quarter is 1.0 or below may be referred to the Undergraduate Curriculum Committee, which may place the student on academic probation or drop, regardless of the student's previous record, if such action is deemed advisable.

c. A graduate student whose scholastic average for any quarter is 2.0 or below may be placed on academic probation or drop, regardless of the student's previous record.

d. A student on academic probation whose scholastic average for the quarter of probation is below the minimum satisfactory scholarship requirement and whose overall scholastic average is below the minimum satisfactory scholarship requirement shall be dropped for unsatisfactory scholarship and dropped from the rolls.

e. The record of a student on academic probation whose overall scholastic record is satisfactory but whose quarter average is unsatisfactory may be reviewed by the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate. The student may be dropped or may be continued on academic probation.

7. Academic review

A student who normally would be dropped from the rolls for academic deficiencies but appears from the record not to have completed the quarter may be placed on academic review. This is a temporary standing that makes the student ineligible for registration. If no acceptable explanation is given within a reasonable time, the standing is changed to drop.

8. The scholastic standing regulations given above for graduate students do not preclude a school from having more rigorous requirements.

9. Part-time students

a. These regulations do not necessarily apply to students scheduling fewer than twelve credit hours.

b. The scholastic standing of these students may be determined by either the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, with the decision based on individual merit in each case.

D. Change of Major

1. Undergraduate students, by filing the required form, will be permitted one unrestricted transfer between majors (including undecided) until they have accumulated credit for ninety hours. After ninety hours or upon subsequent request for transfer, the transfer will be permitted at the discretion of the school that the student is seeking to enter. (Note: Certain majors, because of high enrollment, have been granted a waiver of the one unrestricted transfer regulation. Students should consult with the individual school concerning its current transfer policy.)

2. Graduate students, by filing the required form, may transfer with the concurrence of the schools involved and the Graduate Dean.

E. Exceptions

Exceptions to these scholastic regulations may be made by the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, whenever a consideration of the student's complete record indicates that the application of a specific regulation will result in injustice.

VI. Deficiencies

A. General

1. A student who has received a grade of I, F, or U in a course has a deficiency in the course.

2. A student whose final grade is F or U has a failure in that course. He must repeat and pass the course in class before credit will be allowed. (See B.4).

B. Removal of Deficiencies

1. An incomplete in a course must be removed and the grade change reported to the registrar not later than the end of the student's next quarter of residence.

2. The grade of I will not be counted in the computation of the student's point average at the end of the quarter in which the grade is received, nor in any quarter immediately following in which the student is not enrolled. If the I is not removed and the change of grade reported by the end of the student's next quarter in residence, the grade of I will be changed to an F on the student's permanent record and will count thereafter as an F in the computation of point average. (Note: Registering and repeating a course in which an I grade has previously been assigned will not remove the outstanding I grade.)

3. A student who has a failure in a required course must schedule that course the next time it is offered while the student is in residence.

4. A degree candidate who has a single course deficiency for graduation will be

permitted one re-examination not later than seventy-two hours before commencement exercises and thereafter one examination per annum until the deficiency is removed, with the dates of the annual periods beginning thirty calendar days after the commencement exercises. This re-examination must be authorized by the registrar before being scheduled. The examination will be graded *S* or *U* and grade so recorded. The previously assigned *F* or *U* will remain a part of the record.

5. A degree candidate who has otherwise completed all requirements for graduation and who has an incomplete in laboratory work taken during his final quarter in residence may remove the incomplete at the convenience of the department of instruction concerned.

VII. Withdrawal from School

A. General

1. A student eighteen years of age or older may withdraw from school upon the submission of a formal resignation during the first five weeks of the quarter.

2. A student under eighteen years of age must include written permission from parents or guardian along with a formal resignation in order to withdraw from school before the official close of a quarter.

3. The proper forms for withdrawal are available from the Office of the Registrar. Students who withdraw without proper notification will receive grades of *F*, *U*, or *I* for the courses in which they were registered that quarter.

4. Permission and/or formal resignation are not required when a student has completed an official school quarter and does not register for the succeeding quarter.

5. See Section IV.A.3 for further information on withdrawal.

B. Readmission

See Section VIII for the regulations concerning readmission.

VIII. Readmission

A. General

1. A student who for any reason has remained out of school one or more quarters

excluding the summer quarter must apply for readmission. This application, with all pertinent supporting information (except possibly another college transcript—see 2 below), must be submitted to the Registrar before the deadline for the quarter for which readmission is requested, as listed below:

Fall—August 1   Spring—March 1
Winter—December 1   Summer—June 1
Applications received after these deadlines will not be accepted.

2. Students who have attended other colleges should plan their readmission so as to allow ample time for official transcripts from those colleges to be sent to the Georgia Institute of Technology. If official transcripts have not been received prior to the last day of registration, the student seeking readmission will not be allowed to complete registration.

B. Readmission

1. A student who has been dropped once for unsatisfactory scholarship will ordinarily not be readmitted. A student who seeks an exception to this rule must have been out of the Institute for at least one quarter of the academic year and have had a conference with the major school concerning the readmission prior to the appropriate date listed in VIII.A.1 above. Because the summer quarter is not included in the academic year, students who are dropped at the end of the spring quarter will not be eligible for readmission until the beginning of the following winter quarter.

2. A student who is dropped a second time for unsatisfactory scholarship will not be readmitted to the Institute.

C. Transfer Credit

1. Course work pursued at another institution after dismissal from Georgia Tech for unsatisfactory scholarship may be considered as evidence for readmission.

2. If readmitted, a student will not necessarily be given transfer credit for work taken at another institution after dismissal from Georgia Tech.

3. In no case will credit be allowed (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech.

IX. Scheduling

A. General

1. Each student is strongly advised each quarter to schedule all prerequisite courses possible and should schedule all back courses before scheduling any advanced courses.

2. In dropping courses from their schedule, students must retain back courses in preference to advanced courses, unless permission to do otherwise is obtained from their school director.

3. The scheduling of back courses is the responsibility of the students, and they will be held accountable therefor.

4. Subject to approval by a faculty adviser, a course may be taken more than once for academic credit. All grades will count in determining the scholastic average, but the course will be counted only once for credit toward a degree.

5. See Sec. X for Institute rules for courses taken on a pass/fail basis.

B. Academic Load

1. The normal load scheduled by an undergraduate student in good standing should not exceed twenty-one credit hours. However, in exceptional cases, a total of twenty-three credit hours may be scheduled with the approval of the school.

2. Maximum credit hour loads are given in Sec. V.C.2, C.3, and C.4. Any hours above these limits must have prior approval of the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate.

3. Graduate students must maintain a minimum of three credit hours each quarter of enrollment.

C. Auditing of Courses

1. Auditing of courses will be permitted to regularly enrolled students who have obtained the approval of their adviser and the departments concerned. Such courses count at full value in computing the student's load.

2. The grade for auditing is *V* (visitor), and this grade will have no effect on the student's grade point average.

3. No academic credit is granted for audit participation in a course.

4. Students are not permitted to change to and from an auditing status except through the regular procedures for schedule change or withdrawal.

X. Pass/Fail System

A. General

1. At the option of the student's major school, credit toward a bachelor's degree may be allowed for courses taken under the pass/fail system and completed with a grade of *pass*.

2. The major school must approve all pass/fail courses included in the final program of study, and students should become aware of school requirements.

3. In graduate programs, thesis research hours will be evaluated on a pass/fail basis.

4. Pass/fail enrollment in any course may be restricted by the school or department offering the course.

5. Students who are permitted to register under the pass/fail system will be so designated on the official class rolls; the grades recorded will be *S* for pass or *U* for failure. These grades will not be included in the calculation of the grade point average and cannot be changed to a grade that will count in the average.

6. Withdrawals from courses taken on a pass/fail basis will follow the same rules that govern withdrawals from courses included in the scholastic average.

B. Credit Hours Permitted

1. The maximum number of pass/fail hours permitted in an undergraduate program of study depends upon the number of credit hours that will be completed at Georgia Tech, as follows:

Hours included in program of study	Hours allowed on pass/fail basis
50 to 89 credit hours	3 credit hours
90 to 134 credit hours	6 credit hours
135 to 179 credit hours	9 credit hours
180 or more credit hours	12 credit hours

2. For a second undergraduate degree, these limitations apply to the credit hours approved for the program of study for that second degree.

3. A master's degree program of study may include up to six course credit hours on a pass/fail basis.

XI. Joint Enrollment at Georgia State University

A. General
1. With the approval of the student's major school, a student may schedule courses at Georgia State University if such courses are not available at Georgia Tech.
2. All registration activities are performed at Georgia Tech.
3. Withdrawals from Georgia State University courses will be performed at Georgia Tech, based on usual withdrawal regulations and procedures, with the exception that there will be no refund of fees.
4. Further information is available from the Office of the Registrar.

B. Eligibility
1. Joint enrollment is available only to degree-seeking juniors, seniors, and graduate students.
2. To participate in joint enrollment, a student must be in good academic standing during the quarter when the application is processed and during the quarter of joint enrollment.

XII. Examinations

A. General
1. All re-examinations, examinations for advanced standing, and special examinations must be authorized by the registrar before being scheduled.
2. If the instructor considers it necessary during an examination, students may be required to present their student identification card to the instructor or an authorized representative.

B. Examinations for Advanced Standing
1. Students who offer satisfactory evidence that they are qualified to do so may receive credit for a course by examination. Such an examination is called an examination for advanced standing.
2. Examinations for advanced standing require the recommendation of the department of instruction in which the course is

offered, payment of the appropriate fee, and authorization by the registrar.
3. Examinations for advanced standing will ordinarily be offered during the week of final examinations.
4. A student will not be allowed to take an examination for advanced standing in a given course more than twice.
5. An examination for advanced standing will be reported with an *S* or *U* grade. Neither grade will be included in the calculation of the scholastic average.

C. Final Examinations for Degree Candidates
A degree candidate will be exempted from examinations during final examination week in the quarter of graduation.

D. Regulations Covering Final Examinations
A student reporting to a final examination room more than fifteen minutes after the scheduled starting time shall not be allowed to take the examination unless a satisfactory explanation is presented to the instructor conducting the examination.

XIII. Undergraduate Degrees

A. General
1. To be considered for admission to candidacy for a degree, a student must have passed the Regents' Test and must make a formal petition for the degree during the quarter preceding the final quarter in residence. A petition for degree will not be accepted until the Regents' Test has been passed.
2. Students desiring to withdraw their name from the rolls of degree candidates must formally withdraw the petition for degree before the end of the eighth week of the quarter.
3. A degree program may include a maximum of six hours of basic ROTC and a maximum of nine hours of advanced ROTC.
4. The diploma of a candidate for a degree shall bear the date of the commencement at which the degree is awarded.

B. Fifty-hour Rule
No student may be considered a candidate for a degree unless the final fifty credit hours

required for the degree are earned in residence at Georgia Tech.

C. Ten-year Rule
Work completed more than ten years prior to commencement must be validated by special examinations before it can be counted toward a degree.

D. Requirements for a Degree
1. To be a candidate for a degree, undergraduate students must have passed all courses required for the degree, must have a scholastic average for their entire academic program of at least 2.0, and must have done creditable work in their departmental courses so as to merit the recommendation for the degree by the director and faculty of their school.
2. Students, with the approval of their school or specialization, may satisfy the requirements for an undergraduate degree by meeting all of the requirements listed in any one of the catalogs in effect during the period of their enrollment in the Institute. A catalog is in effect for a student only if the student's date of matriculation is prior to the ending date of the spring quarter shown in the calendar printed in the catalog concerned.
3. Constitution and history examinations.
   a. The Georgia law as amended March 4, 1953, requires that before graduation all students pass examinations or pass comparable courses in United States and Georgia history as well as United States and Georgia Constitution.
   b. Courses that may be substituted for the United States and Georgia Constitution and history examinations are listed in this catalog in the section for the Department of Social Sciences.
4. Regents' testing program.
   All students completing requirements for baccalaureate degrees are required by the University System of Georgia to pass an examination designed to measure proficiency in reading and English composition. This examination is known as the Regents' Test. It must be passed before a petition for graduation will be accepted. Students should obtain further information from the registrar.
5. Physical education requirement.

a. Unless medically disqualified, all students are required to complete PE 1040 or 1061 before graduation.
   b. See Sec. XV for a complete description of the physical education requirements at Georgia Tech.

E. Graduation with Academic Distinction
1. For graduation with highest honor, the minimum scholastic average shall be 3.6. For graduation with high honor, the minimum scholastic average shall be 3.4. For graduation with honor, the minimum scholastic average shall be 3.2.
2. A student must have earned at least one hundred credit hours at Georgia Tech to graduate with highest honor, with high honor, or with honor.

F. Second Undergraduate Degree
1. A student enrolled for a second undergraduate degree shall be classified an undergraduate student.
2. To be a candidate for a second undergraduate degree, a student must have the recommendation of the director of the school concerned and the approval of the Undergraduate Curriculum Committee.
3. To obtain a second undergraduate degree, a student must complete all major required courses for the degree and earn credit for a total of at least fifty credit hours in excess of the requirement for any previous degrees earned.
4. All regulations in Section XIII A, B, and C apply to students completing second degrees.

XIV. Graduate Degrees
A complete description of Institute requirements for the master's and doctor's degrees is given in this catalog in the section titled "Information for Graduate Students." Also see Section XIII.A.2 for a regulation concerning withdrawal of a petition for degree.

XV. Physical Education

A. General
1. All students entering Georgia Tech as freshmen are required to complete satisfactorily three credit hours in physical education courses, PE 1040 or PE 1061.

2. Transfer students will be granted credit for comparable physical education courses completed at other institutions.

B. Medical Exemptions

1. The Health Information Record on file with the director of Health will be used to determine any medical exemptions from physical education courses. All certificates of disability from personal physicians must be endorsed by the Student Health Services before they will be accepted by the Department of Physical Education and Recreation.

XVI. Student Motor Vehicles

Students desiring to operate motor vehicles on campus are subject to all rules set forth by the Georgia Tech motor vehicle regulations.

XVII. Medical Regulations

A. General

1. No student with a contagious disease may stay in a dormitory or fraternity house or attend class. Any illness with fever should be considered a contagious disease until checked by a physician. Every student is held individually responsible for immediately reporting such illness to the infirmary.
2. A current Health Information Record and a consent-for-treatment form must be on file with the director of Health.

B. Infirmary Regulations

Students must conform to infirmary regulations, as posted in the infirmary, while confined as patients in the infirmary.

XVIII. Extracurricular Activities

A. Participation

1. In order to be eligible for participation in extracurricular activities, a student must satisfy the following requirements:
   a. be enrolled in a degree program;
   b. maintain a schedule with at least six credit hours on a credit basis or be a student in the Cooperative Division on work quarter;
   c. not be on academic or disciplinary probation.
2. Participation also requires satisfaction of any additional requirements established by

the Student Activities Committee of the Academic Senate.

B. Scheduling of Events

1. During the first week of each quarter, a schedule of public performances to be sponsored by each student organization must be submitted to the Division of Student Affairs for approval by the Student Academic and Financial Affairs Committee of the Academic Senate.
2. All student organizations must make written application to, and receive permission from, the Division of Student Affairs to hold a social function. The request must be submitted at least one week before the date of the activity, and the permission must be received before making any agreements in connection with the function.
3. In each quarter, the weekend before final examinations is closed to student-sponsored extracurricular events.

C. Student Organizations

Requirements and standards for chartering a student organization are established by the Student Activities Committee of the Academic Senate and are available from the Division of Student Affairs.

D. Fraternity and Sorority Regulations

1. To be eligible for initiation, a student must be a full-time student not on academic or disciplinary probation.
2. The initiation of any individual must be registered with and approved by the Division of Student Affairs prior to the initiation.
3. The individual must meet all Georgia Tech Interfraternity Council (I.F.C.) or Panhellenic requirements concerning initiation.
4. All fraternities and sororities are subject to the rules established by the Georgia Tech I.F.C./Panhellenic.

E. Intercollegiate Athletic Regulations

1. To be eligible for intercollegiate athletic competition, a student must be enrolled in a degree program, be carrying a workload of at least twelve credit hours, and not be on academic or disciplinary probation. In addition, he or she must be making satisfactory progress toward a degree and meet any further requirements of the NCAA or other governing organization; see the athletic director for details.

2. No student may be excused from regularly scheduled classes for athletic practice.
3. No student may participate in more than two sports in intercollegiate competition in any school year, except by permission of the Division of Student Affairs. Being manager or assistant manager is counted as participation within the meaning of this rule.

XIX. Student Conduct Code

A. General

A student enrolling in the Georgia Institute of Technology assumes an obligation to conduct himself or herself in a manner compatible with the Institute's function as an educational institution. Actions considered inimical to the Institute and subject to discipline fall into the categories of academic and nonacademic misconduct.

B. Academic Misconduct

Academic misconduct is any act that does or could improperly distort student grades or other student academic records. Such acts include but need not be limited to the following:
1. Possessing, using, or exchanging improperly acquired written or verbal information in the preparation of any essay, laboratory report, examination, or other assignment included in an academic course;
2. Substitution for, or unauthorized collaboration with, a student in the commission of academic requirements;
3. Submission of material that is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating the authorship (plagiarism);
4. False claims of performance for work that has been submitted by the claimant;
5. Alteration or insertion of any academic grade or rating so as to obtain unearned academic credit;
6. Deliberate falsification of a written or verbal statement of fact to a member of the faculty so as to obtain unearned academic credit;
7. Forgery, alteration, or misuse of any Institute document relating to the academic status of the student.

C. Nonacademic Misconduct

Nonacademic misconduct includes the following specifically prohibited acts whenever, unless otherwise stated, such acts occur on Institute owned or controlled property or Institute-related premises:
1. Alcohol abuse, including
   a. conspicuous or flagrant possession of alcoholic beverage;
   b. intoxication made manifest by boisterousness, rowdiness, obscene or indecent conduct or appearance, or vulgar, profane, lewd, or unbecoming language;
   c. disorderly conduct associated with the use of alcoholic beverages.
2. Pushing, unjustifiably striking or physically assaulting, or otherwise intentionally threatening or endangering the person of any member of the faculty, administration, staff, or student body, or any visitor to the campus.
3. Disorderly conduct, including
   a. breach of the peace or obstruction or disruption of teaching, research, administration, disciplinary procedure, or other Institute activities, including its public service functions or other authorized activities;
   b. refusal to vacate a building, street, sidewalk, driveway, or other facility when directed to do so by any properly identified Institute faculty, administration, or staff personnel while these persons are acting in the performance of their duties;
   c. lewd, indecent or obscene conduct or expression;
   d. failure to comply with instructions or directions of any properly identified faculty, administration, or staff personnel while these persons are acting in the performance of their duties.
4. Drug abuse, including the use or possession (without valid medical or dental prescriptions), manufacture, furnishing, sale, or any distribution of any narcotic or dangerous drug controlled by law; this provision is not intended to regulate alcoholic beverages, which are covered in Section 1 above;
5. Unauthorized use of college facilities including:

a. unauthorized entry into any Institute building, office, or other facility or remaining in any building after normal closing hours;

b. unauthorized use of any Institute telephone facility or of any other Institute facilities;

c. possessing, using, making, or causing to be made any key for any Institute facility without proper authorization;

d. unauthorized use of another student or faculty member's password to gain access to the computer or computer output. This includes but is not limited to any knowing and willing use of fraudulent means to process computer programs and access computer files.

6. Furnishing false information to any Institute official or offering false statement in any Institute disciplinary hearing;

7. Forgery, alteration, or misuse of any Institute document, record, or identification;

8. Any hazing action that tends to cause or allow physical or mental suffering in connection with rites or ceremonies of induction, initiation, or orientation into Institute life or into the life of any Institute group or organization;

9. Safety violations, including

a. intentional false reporting of a fire or that any explosive device has been placed on Institute property;

b. tampering with fire-fighting equipment, safety devices, or other emergency or safety equipment;

c. setting an unauthorized fire;

d. possession of unauthorized fireworks, firearms, ammunition, or dangerous weapons or materials;

e. unauthorized sale, possession, furnishing, or use of any incendiary device or bomb;

f. Use of smoking tobacco, in any form, in facilities or areas posted with "No Smoking" signs or where smoking has been prohibited by any faculty member or other official.

10. Theft and/or unauthorized possession of Institute property or property of a member of the Institute community or campus visitor;

11. Malicious or unauthorized damage or destruction to Institute property or property belonging to any member of the Institute community or campus visitor;

12. Violation of rules governing residence in Institute owned or controlled property such as dormitories, family housing, fraternities, and organization housing;

13. Playing of games of skill or chance for money or other items of value;

14. Failure to remit, return, or submit financial obligations, property or records of the Institute, within the time prescribed by the Institute;

15. Knowingly acting in concert with any other person to perform an unlawful act or to violate an Institute regulation or policy;

16. Violations of the Georgia Tech Motor Vehicle Regulations;

17. Violation of the Regents' Statement on Disruptive Behavior, the full text of which is given in Section XX;

18. Repeated violations of the published rules and regulations of the Institute, which cumulatively indicate an unwillingness or inability to conform to the Institute standards for student life;

19. Violation of the conduct code, wherever it may occur, violation of the laws of any city, county, state, or the United States, where the violation creates a clear and present danger of material interference with the normal or orderly processes of the Institute or its requirements of appropriate discipline.

XX. Regents' Statement on Disruptive Behavior

The following is the policy of the Board of Regents regarding disruptive behavior in any institution of the University System. The rights, responsibilities, and prohibitions contained in this statement are incorporated as a part of these regulations.

The Board of Regents of the University System of Georgia reaffirms its policies to fully support freedom of expression by each member of the academic community and to preserve and protect the rights and freedom of its faculty members and students to engage in debate, discussion, peaceful and nondisruptive protests, and dissent. The following statement relates specifically to the problem described below. It does not change or in any way infringe upon the Board's existing policies and practices in support of

freedom of expression and action. Rather, it is considered necessary to combat the ultimate effect of irresponsible disruptive and obstructive actions by students and faculty that tend to destroy academic freedom and the institutional structures through which it operates.

In recent years, a new and serious problem has appeared on many college and university campuses in the nation. Some students, faculty members, and others have on occasion engaged in demonstrations, sit-ins, and other activities that have clearly and deliberately interfered with the regular and orderly operation of the institution concerned. Typically, these actions have been the physical occupation of a building or campus area for a protracted period of time or the use or display of verbal or written obscenities involving indecent or disorderly conduct.

These actions have gone beyond all heretofore recognized bounds of meetings for discussion, persuasion, or even protest in that (1) acquiescence to demands of the demonstrators is the condition for dispersal and (2) the reasonable and written directions of institutional officials to disperse have been ignored. Such activities thus have become clearly recognizable as an action of force, operating outside all established channels on the campus, including that of intellectual debate and persuasion, which are at the very heart of education.

The Board of Regents is deeply concerned by this new problem. Under the Constitution of the state of Georgia, under all applicable court rulings and in keeping with the tradition of higher education in the United States, the Board is ultimately responsible for the orderly operation of the several institutions of the University System and the preservation of academic freedom in these institutions. The Board cannot and will not divest itself of this responsibility.

Of equal or even greater importance, such action of force as has been described above destroys the very essence of higher education. This essence is found in the unhampered freedom to study, investigate, write, speak, and debate on any aspect or issue of life. This freedom, which reaches its

full flowering on college and university campuses, is an essential part of American democracy, comparable to the jury system or the electoral process.

For these reasons and in order to respond directly and specifically to this new problem, the Board of Regents stipulates that any student, faculty member, administrator, or employee, acting individually or in concert with others, who clearly obstructs, disrupts, or attempts to obstruct or disrupt any teaching, research, administrative, disciplinary, public service activity, or any other activity authorized to be discharged or held on any campus of the University System of Georgia is considered by the Board to have committed an act of gross irresponsibility and shall be subject to disciplinary procedures, possibly resulting in dismissal or termination of employment.

The Board reaffirms its belief that all segments of the academic community are under a strong obligation and have a mutual responsibility to protect the campus community from disorderly, disruptive, or obstructive actions, which interfere with academic pursuits of teaching, learning, and other campus activities.

The Board of Regents understands that this policy is consistent with resolutions adopted by the American Association of University Professors in April, 1968, by the Association of American Colleges in January, 1968, and by the executive committee of the Association for Higher Education in March, 1968, condemning actions taken to disrupt the operations of institutions of higher education.

XXI. Disciplinary Administration

A. Disciplinary Procedures

1. All acts of misconduct (except violations of motor vehicle regulations) on the part of students shall be reported to the vice-president for Student Affairs, who is designated the principal administrator to enforce Institute disciplinary measures as they pertain to student academic or nonacademic misconduct.

2. The vice-president for Student Affairs shall investigate alleged acts of student

misconduct. If the investigation indicates that further action is necessary, the vice-president for Student Affairs shall notify the accused in writing. This written notification shall contain a statement of the nature of the alleged or suspected misconduct and state the sections of the conduct code the student is alleged to have violated.

3. The vice-president for Student Affairs or the authorized representative will normally confer with the accused student, and at this conference, the student may admit or deny the alleged violation, the student may waive further hearing and appeal(s) in writing and request that the vice-president for Student Affairs take appropriate action, or may request a hearing as specified in 4, 5, or 6 below.

4. Cases of academic misconduct will normally be referred to the Student Honor Committee, which shall hear and try cases involving academic misconduct on the part of any student.

5. Cases of serious nonacademic misconduct that may result in suspension or expulsion will normally be referred to the Graduate Judiciary or Undergraduate Judiciary Cabinet, which shall hear and try these cases. This does not preclude possible legal actions by appropriate law enforcement agencies in those cases of nonacademic misconduct in violation of federal, state, or local law.

6. If the case does not involve possible suspension or expulsion, the vice-president for Student Affairs ordinarily shall make full disposition of the case except that he or she, at the request of the accused or for good cause, may refer any case of nonacademic misconduct to the Graduate Judiciary or Undergraduate Judiciary Cabinet.

7. Students accused of an act of academic misconduct or nonacademic misconduct are encouraged to notify their parents or guardian of the charges. Parents or guardian will, if requested, be granted a conference with the vice-president for Student Affairs prior to the hearing.

8. An accused student will continue to attend classes and required Institute functions until the hearing is held and a decision is rendered. Exceptions to this will be made when the student's presence may create a clear and present danger of materially interfering with the Institute's normal operations or the requirements of appropriate Institute discipline. In such cases, the vice-president for Student Affairs may impose temporary protective measures, including interim suspension, pending the hearing; such protective measure, if applied, will be without reasonably avoidable prejudice to the student.

B. Student Honor Committee

1. The Student Honor Committee shall consist of four members of the corps of instruction elected from the Academic Senate and two undergraduate students with at least junior standing elected by the Student Council and one graduate student elected by the Graduate Student Senate. Student members must have good academic standing and must not be on disciplinary probation. The chairman shall be elected annually by the committee from among the Academic Senate members. The secretary shall be appointed by the chairman.

2. The committee shall hear and try all cases referred to it involving alleged dishonesty in academic matters on the part of students. The decision in the case shall be transmitted to the office or offices responsible for recording it, for notifying the student officially, and for implementing the action.

3. In its distributed minutes and in the annual report of its activities and findings, the committee shall preserve the anonymity of individuals by generalizing the issues involved and the actions taken.

C. Student Judiciary

1. The Graduate Judiciary shall consist of a graduate student chairman and six graduate student justices. The graduate student justices and chairman shall be currently enrolled, full-time graduate students in good academic standing and not on disciplinary probation. They are appointed by the graduate student body president and approved by the Graduate Student Senate. The Graduate Judiciary shall normally hear all cases of graduate student nonacademic misconduct in which there is the possibility of suspension or expulsion of the accused student.

2. The Undergraduate Judiciary Cabinet shall consist of an undergraduate student chairman and ten undergraduate student justices. The undergraduate student justices and chairman will be currently enrolled, full-time undergraduate students in good academic standing and not on disciplinary probation. They are appointed by the student body president and approved by the Student Council. The Undergraduate Judiciary Cabinet shall normally hear all cases of undergraduate student nonacademic misconduct in which there is a possibility of suspension or expulsion of the accused student.

D. Procedural Rights of the Accused

Students accused of an act of misconduct and summoned to a hearing before the Student Honor Committee, Graduate Judiciary, or Undergraduate Judiciary Cabinet have the right to

1. be accompanied by an adviser of their choice;
2. remain silent with no inference of guilt drawn therefrom;
3. question the complainant;
4. present evidence in their behalf;
5. call pertinent witnesses in their behalf;
6. cross-examine witnesses;
7. challenge and unseat as many as four student justices in Undergraduate Judiciary Cabinet hearings (the chairman cannot be struck; a quorum of six student justices and the chairman must remain);
8. appeal.

E. Hearing Procedures

1. The chairman of the appropriate hearing body shall set the date, time, and place of the hearing, shall notify the members of the hearing body, and shall summon all principals in the case (defendants and witnesses).

2. The chairman of the appropriate hearing body shall notify the accused student in writing at least three days in advance of the scheduled hearing. The written notification should, if reasonably possible, be hand delivered; if not reasonably possible, notification should be by registered mail to the student's local address. The written notification should specify

    a. the date, time, and place for the hearing;
    b. the nature of the alleged or suspected misconduct with which the student is accused, with sufficient particularity to ensure opportunity to prepare for the hearing; and
    c. names of witnesses scheduled to appear.

3. Decisions for the hearing body shall be by majority vote. A quorum for the Student Honor Committee shall consist of five members, three faculty members, and two students. A quorum for the Undergraduate Judiciary Cabinet shall consist of the chairman and six justices. A quorum for the Graduate Judiciary shall consist of the chairman and four justices.

4. Members of the hearing body shall disqualify themselves if their personal involvement in the hearing is of such a nature as to prejudice the case.

5. The hearings of the Student Honor Committee, Graduate Judiciary, and Undergraduate Judiciary Cabinet shall ordinarily be closed except for the accused, the accused's adviser, and those directly involved; exceptions may be made at the discretion of the chairman. The hearing body may exclude any person who may be reasonably expected to interfere materially with the hearing or who does interfere materially with the hearing. Hearing body deliberations are closed to all but the hearing body members.

6. The hearing body shall make a tape recording and/or summary transcription of the proceedings.

7. The hearing body shall provide a brief written summary of each case with recommendations for appropriate disciplinary action to the vice-president for Student Affairs and to the student involved.

8. The vice-president for Student Affairs will review the case and recommendations and implement disciplinary action.

F. Disciplinary Measures

For violations of Institute rules and regulations or for acts of student misconduct, academic or nonacademic, the following disciplinary measures may be taken. This list is not exhaustive and may be modified to meet particular circumstances in any case.

1. Expulsion—permanent severance of the student's relationship with the Institute.

2. Disciplinary suspension—temporary severance of the student's relationship with the Institute for a specific period of time, though not less than one quarter.

A student expelled or suspended shall leave the campus and not visit the campus during the period of suspension or expulsion, except when on official school business. To violate this stipulation would adversely affect the student's chances for readmission.

3. Reprimand—an oral and/or written statement of disapproval issued to the student.

4. Restriction—exclusion from participation in social activities and loss of identification card privileges.

5. Disciplinary probation—notice to the student that any further major disciplinary violation may result in suspension or expulsion; may include setting of restrictions and/or issuing a reprimand. A student on disciplinary probation is not in good standing and may not participate in extracurricular activities.

6. Fines.

7. Restitution—reimbursement for damage to or misappropriation of property; this may take the form of appropriate service or other compensation.

8. Forced withdrawal—withdrawal from the academic course within which the offense occurred without credit for the course.

9. Change in grade—grade change for the course in which the offense occurred.

G. Appeal Procedures

1. If accused students or accusers are dissatisfied with the action taken by the vice-president for Student Affairs, they may appeal the case in writing to the president of Georgia Tech within five days after the action about which there is a complaint. Such appeal shall recite all reasons for dissatisfaction with the previous decision.

2. The president, within five days, shall refer the appeal to the Student Grievance and Appeal Committee. This committee shall review all facts and circumstances connected with the case and within five days shall make its findings and report thereon to the president. After consideration of the committee's report, the president within five days shall make a decision that will be final so far as the Institute is concerned.

3. The Student Grievance and Appeal Committee shall consist of three members of the corps of instruction elected from the Academic Senate and two students with at least junior standing elected jointly by the Student Council and the Graduate Senate. The chairman shall be elected annually by the committee from among the elected Academic Senate members. The secretary shall be appointed by the chairman.

4. The Board of Regents of the University System of Georgia is the final appellate authority for all cases involving students who have been suspended or expelled. Should aggrieved persons be dissatisfied with the decision of the president, they may apply to the Board of Regents, without prejudice to their position, for a review of the decision. The application for review shall be submitted in writing to the executive secretary of the Board within a period of twenty days following the decision of the president. This application for review shall state the decision complained of and the redress desired. A review of the Board is not a matter of right but is within the sound discretion of the Board. If the application for review is granted, the Board, or a committee of the Board shall investigate the matter thoroughly and render its decision thereon within sixty days from the filing date of the application for review or from the date of any hearing that may be held thereon. The decision of the Board shall be final and binding for all purposes.

XXII. Exceptions

Where appeals are not otherwise specified, exceptions to these regulations may be made by the appropriate faculty committee upon petition by the student and recommendation of the student's school or department. Blanket exceptions that have the effect of amending these regulations shall be referred to the Academic Senate for approval.

Administration

Board of Regents

The Georgia Institute of Technology is one of the educational institutions constituting the University System of Georgia. The university system is governed by a fifteen-member Board of Regents, the members of which are appointed to seven-year terms by the governor of Georgia. The members of the Board of Regents are listed below.

John Henry Anderson, Jr.,
Hawkinsville . . . . State-at-Large
Marie W. Dodd, Roswell . . . . State-at-Large
Carolyn D. Yancy, Atlanta . . . State-at-Large
Joseph D. Greene, Thomson . State-at-Large
Dr. John E. Skandalakis,
Atlanta . . . . State-at-Large
Arthur M. Gignilliat, Jr.,
Savannah . . . . First District
William T. Divine, Jr.,
Albany . . . . Second District
William B. Turner,
Columbus . . . . Third District
Jackie M. Ward, Atlanta,
Vice-chair . . . . Fourth District
Elridge W. McMillan,
Atlanta, Chair . . . . Fifth District
Edgar L. Rhodes, Bremen . . . Sixth District
Lloyd L. Summer, Jr.,
Rome . . . . Seventh District
Thomas H. Frier, Douglas . . . Eighth District
Sidney O. Smith,
Gainesville . . . . Ninth District
John W. Robinson, Jr.,
Winder . . . . Tenth District

Chancellor of the University System and the Administrative Staff

Chancellor H. Dean Propst is the chief administrative officer of the University System and the chief executive officer of the Board of Regents. Members of his administrative staff are the following:

Henry G. Neal, executive secretary
William Ray Cleere, vice-chancellor, Academic Affairs
Frederick O. Branch, vice-chancellor, Facilities
Jacob H. Wamsley, vice-chancellor, Fiscal Affairs
Thomas F. McDonald, vice-chancellor, Student Services
Haskin R. Pounds, vice-chancellor, Planning

The University System of Georgia

Since 1932, all state-operated institutions of higher education in Georgia, including the Georgia Institute of Technology, have sought to accomplish their goals of instruction, public service, and research through their affiliation with the University System of Georgia. Governed by the fifteen-member constitutional Board of Regents under the administration of the chancellor, the four universities, fifteen senior colleges, and fifteen junior colleges that compose the System retain a high degree of autonomy while cooperating with member institutions within the structure of Board policy. In addition to the formulation and administration of policy, the Board of Regents is responsible for requesting appropriations from the Georgia legislature and for allocating these funds to member institutions.

To provide students in Georgia with quality instruction leading to a variety of degrees, the Board of Regents establishes minimum academic standards, granting to each member institution the prerogative of establishing higher standards. In addition, the Board has instituted a core curriculum for freshmen and sophomores whose educational goal is a degree beyond the associate level, in order to facilitate the transfer of credit within the University System. This curriculum requires ninety quarter hours in general studies—humanities, social sciences, mathematics, and natural sciences—and thirty in the student's chosen major area. Besides providing a foundation for sound instruction, the Board encourages public service and continuing education programs, including lectures, conferences, short courses, advisory services, extension courses, and teacher education consortiums. The Board also encourages research related to the educational objectives of the institutions and originating in societal need.

Appointed by the governor and confirmed by the Georgia Senate, the members of the Board of Regents—five from the state at large and one from each of the state's ten Congressional districts—serve for seven-year terms; the chancellor, who is not a member of the Board, is chief executive and administrative officer for the Board and the University System. Each institution has as its executive head a president whose election is recommended by the chancellor and approved by the Board.

● Dalton
● Dahlonega
● Gainesville
● Rome
● Athens
● Marietta
● Decatur
Atlanta
● Carrollton ● Morrow
● Augusta
● Barnesville
● Milledgeville
● Macon
● Swainsboro
Statesboro ●
● Columbus ● Fort Valley
● Cochran
Savannah
● Americus
● Albany ● Tifton ● Douglas
Brunswick
Waycross
Bainbridge
● Valdosta

● Locations of Universities and Colleges
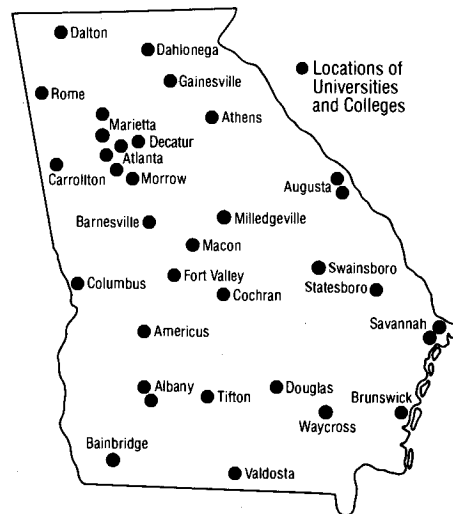
Member Institutions

Key

h—On-campus Student Housing Facilities; Degrees Awarded: *A*—Associate; *B*—Bachelor's; *J*—Juris Doctor; *M*—Master's; *S*—Specialist in Education; *D*—Doctor's; *cD*—Doctor's, offered in cooperation with a University System university, with degree awarded by the University.

Universities
Athens 30602
   University of Georgia—*h; A,B,J,M,S,D*
Atlanta 30332
   Georgia Institute of Technology—*h; B,M,D*
Atlanta 30303
   Georgia State University—*A,B,J,M,S,D*
Augusta 30912
   Medical College of Georgia—*h; A,B,M,D*

Senior Colleges
Albany 31705
   Albany State College—*h; B,M*
Americus 31709
   Georgia Southwestern College—*h; A,B,M,S*
Augusta 30910
   Augusta College—*A,B,M,S,cD*
Carrollton 30118
   West Georgia College—*h; A,B,M,S,cD*
Columbus 31993
   Columbus College—*A,B,M,S,cD*
Dahlonega 30597
   North Georgia College—*h; A,B,M*
Fort Valley 31030
   Fort Valley State College—*h; A,B,M*
Marietta 30061
   Kennesaw College—*A,B,M*
Marietta 30060
   Southern College of Technology—*h; A,B*
Milledgeville 31061
   Georgia College—*h; A,B,M,S*
Morrow 30260
   Clayton State College—*A,B*
Savannah 31406
   Armstrong State College—*A,B,M,S*
Savannah 31404
   Savannah State College—*h; A,B,M*
Statesboro 30460
   Georgia Southern College—*h; A,B,M,S,cD*
Valdosta 31698
   Valdosta State College—*h; A,B,M,S,cD*

Junior Colleges
Albany 31707
   Albany Junior College—*A*
Atlanta 30310
   Atlanta Junior College—*A*
Bainbridge 31717
   Bainbridge Junior College—*A*
Barnesville 30204
   Gordon Junior College—*h; A*
Brunswick 31523
   Brunswick Junior College—*A*
Cochran 31014
   Middle Georgia College—*h; A*
Dalton 30720
   Dalton Junior College—*A*
Decatur 30089-0601
   DeKalb Community College—*A*
Douglas 31533
   South Georgia College—*h; A*
Gainesville 30503
   Gainesville Junior College—*A*
Macon 31297
   Macon Junior College—*A*
Rome 30163
   Floyd Junior College—*A*
Swainsboro 30401
   Emanuel County Junior College—*A*
Tifton 31793
   Abraham Baldwin Agricultural College—*h; A*
Waycross 31501
   Waycross Junior College—*A*

University System of Georgia
244 Washington Street, S.W.
Atlanta, Georgia 30334

Institutional Administration

President
Henry C. Bourne, Jr., Sc.D., *acting president*
James R. Stevenson, Ph.D., *executive assistant to the president*
Janice Gosdin-Sangster, B.S., *assistant to the president*

Academic Affairs
John W. Hooper, Ph.D., *acting vice-president, Academic Affairs*
E. Jo Baker, Ph.D., *associate vice-president, Academic Affairs*
William J. Lnenicka, Ph.D., *associate vice-Academic Affairs*
Gary Poehlein, Ph.D., *associate vice-president, Graduate Studies and Research*
David J. McGill, Ph.D., *director, Center for Enhancement of Teaching and Learning*
William J. Gamble, Jr., Ph.D., *director, Office of Minority Educational Development*

Advanced Technology Development Center
Richard T. Meyer, Ph.D., *director*

Business and Finance
Richard Fuller, Jr., Ph.D., *vice-president, Business and Finance*
C. Evan Crosby, B.S., *associate vice-president, Finance*
Michael Brandon, B.S., *director, Information Services*
Delores Gaddis, *director, Purchasing*
Joel Hubbard, M.B.A., C.P.A., *director, Accounting Services*
H. T. Marshall, LL.B., C.P.A., *director, Internal Auditing*
Frank Murphy, B.A., *director, Property Control*
John Gibson, Ph.D., *director, Personnel*
Billy B. Portwood, LL.B., *director, Budgets*
Jack Vickery, M.P.A., *director, Campus Police*
Roger E. Wehrle, B.S., *director, Auxiliary Enterprises*

David Welch, B.S., *director, Grants and Contracts*

College of Architecture
William L. Fash, M.Arch., *dean*
John A. Kelly, M.Arch., *associate dean*
Arthur F. Beckum, Jr., M.F.A., *assistant dean*

College of Engineering
William M. Sangster, Ph.D., *dean*
W. Denney Freeston, Ph.D., *associate dean*
Lytia Howard, Ph.D., *director, Special Programs*
Madelyne B. Watson, *assistant to the dean*

College of Management
Gerald J. Day, D.B.A., *dean*
H. Joseph Reitz, Jr., Ph.D., *associate dean*
Andrew J. Cooper III, Ph.D., *assistant dean/administration*
Marilu McCarty, Ph.D., *assistant dean/academic programs*

College of Sciences and Liberal Studies
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Warren Heemann, M.A., *vice-president*
Cecil R. Phillips, M.S., *associate vice-president*
Charles E. Gearing, Ph.D., *associate vice-president*
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Thomas K. Hamall, *director, Government Relations*
Charles E. Harmon, A.B., *director, News Bureau*
Catherine C. Inabnit, M.S., *director, Parents and Faculty Programs*
Bonnie B. Johnson, M.B.A., *director, Special Gifts*
William T. Lee, B.S., *director, Planned Giving*
Patrick J. McKenna, LL.M., *director and secretary, Georgia Tech Foundation*
Linda W. McNay, M.B.A., *director, Annual Giving*

Mary Kay Murphy, Ph.D., *director, Foundation Relations and Friends Program*
James B. Osborne, Ed.D., *director, Corporate Relations and Placement*
Michael Polak, *director, Joint Tech-Georgia Development Fund*
Mary E. Stoffregen, M.P.A., *director, Accounting and Administration*
Thomas L. Vitale, B.F.A., *director, Publications*

Contract Administration
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R. M. Bell, M.B.A., *associate director*
M. P. Stombler, Ph.D., *associate director, OCA and director, Office of Technology Transfer*
R. P. Dobb, B.A., J.D., *team leader, Legal Services*
M. V. Drew, B.S., J.D., *team leader, Legal Services*
D. R. Hendrix, B.S., *manager, Program Initiation Division*
D. S. Hasty, *M.S., manager, Contracting Support Division*
R. D. Hardaway, *M.S., manager, Printing and Photographic Center*
G. D. Hutchison, *M.B.A., manager, Program Administration Division*

Cooperative Division
William H. Hitch, B.M.E., *director*
Thomas M. Akins, M.B.A., *associate director*
Anni I. Hubbell, B.A., *assistant director*
Robert W. James, B.S., *assistant director*
Harold B. Simmons, M.B.A., *assistant director*

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Don Kyser, B.S., *associate director*
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Louis J. Zahn, Ph.D., *director, Language Institute*
Leslie G. Callahan, Jr., Ph.D., *acting director, The Institute of Planning/Operational Analysis*
David Edwards, M.S., *assistant director, Video-based Instructional System*

Department of Industrial Education
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Bobby R. Cline, B.B.A., *assistant director*

Georgia Tech Athletic Association
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John O'Neill, B.S., *senior associate athletic director*
Jack Thompson, *associate athletic director*
Bernadette McGlade, B.A., *assistant athletic director for Women's Sports Programs, and head coach, Women's Basketball*
James E. Murphy III, M.S./Mgmt., C.P.A., *assistant athletic director for Finance*
Lawton A. Hydrick, B.S., *assistant athletic director for Operations/Sports Programs*
Scott Zolke, B.S., J.D., *assistant athletic director for Academics-Legal Interpretations*

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Thomas E. Stelson, D.Sc., *vice-president for Research*
William H. Borchert, M.S., *vice-president and general manager*

Georgia Tech Research Institute
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Gerald J. Carey, M.S., *associate director*
H. G. Dean, B.S., *associate director*
Robert G. Shackelford, M.S., *associate director*
James C. Wiltse, Ph.D., *associate director*
Patrick J. O'Haye, B.S., *assistant director*

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Helen E. Grenga, Ph.D., *assistant vice-president*

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Rand H. Childs, M.S., *associate director, Computing Services*

Raymond L. Spalding, M.S., *associate director, Computing Services*

Gary G. Watson, M.S., *director, Information Systems and Applications*

James R. Woolen, M.B.A., *associate director, Information Systems and Applications*

Interdisciplinary Programs

Frederick A. Rossini, Ph.D., *director, Office of Interdisciplinary Programs, and director, Technology Policy and Assessment Center*

Stephen D. Antolovich, Ph.D., *director, Fracture and Fatigue Research Laboratory*

Satyanadham Atluri, Sc.D., *director, Computational Mechanics Center*

Eric J. Clayfield, Ph.D., *director, Georgia Mining and Minerals Resources Institute*

Richard A. DeMillo, Ph.D., *director, Software Engineering Research Center*

E. P. Ellington, M.S., *director, Georgia Productivity Center*

Don P. Giddens, Ph.D., and James C. Toler, M.S., *co-directors, Bioengineering Center*

Daniel P. Schrage, D.Sc., *director, Center for Excellence in Rotary Wing Aircraft Technology*

C. H. Grimes, Ph.D., *director, Center on Work Performance Problems*

N. Walter Cox, Ph.D., *director, Microelectronics Research Center*

Bernd Kahn, Ph.D., *director, Environmental Resources Center*

Ratib A. Karam, Ph.D., *director, Nuclear Research Center*

Richard J. Martin, M.I.D., *director, Rehabilitation Technology Center*

John H. Myers, M. Arch., *director, Center for Architectural Conservation*

Justin Myrick, Ph.D., *director, Health Systems Research Center*

Joan Pettigrew, Ph.D., *director, Communication Research Center*

Weston M. Stacey, Ph.D., *director, Fusion Research Center*

Thomas G. Tornabene, Ph.D., *director, Center for Research in Biotechnology*

John A. White, Ph.D., *director, Material Handling Research Center*

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Miriam A. Drake, M.S., *director*

Helen Citron Wiltse, Ph.D., *associate director*

Minority Educational Development

William J. Gamble, Jr., Ph.D., *director*

Facilities

Clyde D. Robbins, Ph.D., *vice-president, Facilities*

James L. Priest, M.B.A., *director, Plant Operations*

David O. Savini, B. Arch., *director, Design and Construction*

Thomas R. Kirby, M.B.A., *manager, Space Utilization*

J. Bradley Satterfield, Jr., B. Arch., *manager, Architectural Services*

Paul vander Horst, B.L.A., *manager, Landscape Architectural Services*

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Frank E. Roper, M.S.I.E., *registrar*

William F. Leslie, M.S., *associate registrar*

James L. Garner, M.S.I.M., *director, Undergraduate Recruiting*

David B. Gray, B.S., *director, Financial Aid*

Jerry L. Hitt, M.Ed., *director, Admissions*

Marla Jo McIver, B.S., *director, Registration*

Annette Satterfield, A.B., *director, Records*

Research

Thomas E. Stelson, D.Sc., *vice-president, Research*

Albert P. Sheppard, Ph.D., *associate vice-president, Research*

Gary W. Poehlein, Ph.D., *associate vice-president, Graduate Studies and Research*

R. M. Boyd, B.S., *director, Radiological Safety*

Charles M. Lampman, M.B.A., *director, Research Administrative Support*

A. Ray Moore, B.S., *director, Research Communications*

Student Affairs

James E. Dull, M.Ed., *vice-president/dean, Student Affairs*

Edwin P. Kohler, M.Ed., *associate vice-president, Student Affairs*

Carole E. Moore, Ph.D., *assistant vice-president, Student Affairs*

Wm. Miller Templeton, M.S., *director, International Student Services and Programs*

J. Nicholas Gordon, M.D., *director, Student Health Services*

M. Jo Ivey, M.E., *director, New Student/Parent Programs*

Gary J. Schwarzmueller, M.S., *director, Housing*

Barbara J. Winship, Ph.D., *director, Student Counseling and Career Planning Center*

Roger E. Wehrle, B.S., *director, Student Center and Auxiliary Services*

Full-time Academic Faculty and Administrators

As of January 10, 1987

After each name the highest earned degree and its source is listed. The academic rank is followed by the individual's major assignment. Professional registration is indicated with the state(s) of registration as follows:
P.E. = Professional Engineer, L.S. = Land Surveyor, R.A. = Registered Architect, L.A. = Landscape Architect, P.G. = Professional Geologist.

Agaram S. Abhiraman, Ph.D.
North Carolina State University Raleigh
Professor, Chemical Engineering

Philip Adler, Jr., Ph.D.
Ohio State University
Professor, Management

Pradeep K. Agrawal, Ph.D.
University of Delaware
Associate Professor, Chemical Engineering

Mustaque Ahmad, Ph.D.
State University of New York, Stony Brook
Assistant Professor, Information and Computer Science

R. Martin Ahrens, Ph.D.
Washington University
Professor, Physics

James M. Akridge, M.S.
University of Maryland
P.E.(Georgia)
Associate Professor, Architecture

Faiz A. Al-Khayyal, Ph.D.
George Washington University
Assistant Professor, Industrial and Systems Engineering

Cecil O. Alford, Ph.D.
Mississippi State University
Professor, Electrical Engineering

Michael D. Allen, M.P.A.
Golden Gate University
Assistant Professor, Air Force ROTC

Phillip E. Allen, Ph.D.
University of Kansas
Schlumberger Professor, Electrical Engineering

Douglas C. Allen, M.L.A.
Harvard University
L.A.(Kentucky)
Associate Professor, Architecture

Fred C. Allvine, D.B.A.
Indiana University, Bloomington
Professor, Management

William F. Ames, M.S.
University of Wisconsin
Director and Regents' Professor, Mathematics

Appiah Amirtharajah, Ph.D.
Iowa State University
Professor, Civil Engineering

Mostafa H. Ammar, Ph.D.
University of Waterloo, Canada
Assistant Professor, Information and Computer Science

Jane C. Ammons, Ph.D.
Georgia Institute of Technology
P.E. (Georgia)
Assistant Professor, Industrial and Systems Engineering

Gary L. Anderson, Ph.D.
Indiana University, Bloomington
Associate Professor, Applied Biology

Alfred D. Andrew, Ph.D.
Stanford University
Associate Professor, Mathematics

Stephen Antolovich, Ph.D.
University of California-Berkeley
Director, Fracture & Fatigue Research Laboratory, Director and Professor, Materials Engineering

William F. Appelbe, Ph.D.
University of British Columbia, Canada
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