AEROSPACE ENGINEERING EDUCATIONAL PROGRAM

ANNUAL REPORT

Prepared for

NASA CENTER OF RESEARCH EXCELLENCE
SCHOOL OF ENGINEERING
NORTH CAROLINA A&T STATE UNIVERSITY

by

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A. AREA SUMMARY

The principle goal of the educational component of NASA CORE is the creation of Aerospace Engineering options in the Mechanical Engineering program at both the undergraduate and graduate levels. To accomplish this goal, a concerted effort during the past year has resulted in detailed plans for the initiation of Aerospace options in both the BSME and MSME programs in the fall of 1993.

All proposed new courses and the BSME Aerospace option curriculum must undergo a lengthy approval process involving two curriculum oversight committees (School of Engineering and University level) and three levels of general faculty approval. Assuming approval is obtained from all levels, the options will officially take effect in Fall '93. In anticipation of this, certain courses in the proposed curriculum are being offered during the current academic year under special topics headings so that current junior level students may graduate in May '94 under the BSME Aerospace option. The proposed undergraduate aerospace option curriculum (along with the regular mechanical engineering curriculum for reference) is attached at the end of this report, and course outlines for the new courses are included in the appendix.

One new permanent faculty member with an aerospace background was added in Fall 1992 to assist with teaching aerospace courses and developing laboratories.
Three existing faculty members, Drs. Craft, Klett and Lai, have participated in developing the aerospace option plans and two undergraduate students have been supported this year under the auspices of the educational component.

B. PROGRAM DEVELOPMENT

Student Tracking Method

The aerospace options in the BSME and MSME programs are currently under development and must pass a lengthy university approval process during the Spring '93 semester, as explained below, before being officially offered beginning in Fall '93.
Tracking of students in the aerospace options will begin at that time.

Strategies to Recruit Underrepresented Minority Students

The majority of our undergraduate students are African Americans. We are recruiting our current undergraduate mechanical engineering students to enter the aerospace option through announcements about the program in classes and on bulletin boards. Certain aerospace courses have been offered under special topic headings for the current Fall '92 semester, and about six undergraduate students have enrolled in these courses. When the program option receives university approval and can be officially advertised, a brochure will be printed descrawing the aerospace engineering option and it will be included in the Mechanical Engineering Undergraduate Handbook and the

University Bulletin. The brochure, in particular, can be used as a recruiting tool at university days, etc.

Equipment Purchased to Develop Teaching Laboratories

The following equipment, software, video tapes and reference texts have been purchased from the first year budget in support of the development of teaching laboratories.

Qty	Description	Cost
3	486 PC for Controls Lab	$ 9,823
4	486 PC for Aero Des Lab	$12,910
1	486 PC for Wind Tunnel Lab	$ 4,030
2	486 PC for Center Support	$ 8,060
5	Laser Printers	$ 8,252
2	Workstations for Aero Design Lab	$29,910
1	Smoke gen for wind tunnel	$ 2,600
2	Adv Aircraft Analysis Software	$ 3,045
2	AIAA aerospace Video courses	$ 4,771
3	Physics of Spaceflight Video tapes	$ 150
6	AIAA aerospace reference books	$ 374
	Total	$83,925

C. CURRICULUM ACTIVITIES

The development of educational programs to support the research activities proposed under the NASA Center of Research Excellence is considered to be vital to the overall success of the center. Work on the educational component began in earnest in May '92 when funds for release time first became available to the group. This report covers the period of activity through November 30, 1992.

During the summer months, undergraduate and graduate curriculums for aerospace options were developed as part of the proposal requirement. During August and September, the proposed curriculum structure was reviewed both internally and by Mr. Larry Taylor of NASA-LRC. As a result, the undergraduate curriculum was updated slightly to include additional emphasis in the controls area. During October and November, the undergraduate aerospace option was further modified to incorporate proposed changes to the existing mechanical engineering curriculum which itself is currently undergoing significant revision. Also during the current Fall '92 semester we have begun a phase-in of the undergraduate aerospace option.

The undergraduate and graduate curricula and the phase-in plan are described in the following sections.

Undergraduate Aerospace Option

The development of the undergraduate aerospace option presented particular difficulties since, at least in the near term, it must exist as an option within the mechanical engineering program and must meet all of the accreditation criteria for mechanical engineering programs as specified by the Accreditation Board for Engineering and Technology (ABET). We have attempted to construct an aerospace program option that: 1) meshes well with the existing mechanical engineering curriculum; 2) meets the required ABET criteria and; 3) provides sufficient background in aerospace engineering to allow a graduate to work in the aerospace field while retaining sufficient fundamental mechanical engineering training to permit a graduate to function well as a mechanical engineer if he/she, for some reason, does not enter the aerospace field.

Toward this end, the attached aerospace option curriculum has been developed. Where possible, existing courses have been replaced by similar courses with an emphasis on aerospace applications. These course substitutions include the following:

Existing ME Curriculum Course	Aerospace Option Substitution
ELEN 442 Survey of Elec Engr	ELEN 410 Linear Sys and Contrl
MEEN 416 Fluid Mechanics	MEEN 415 Aerodynamics
MEEN 442 Appl'd Thermodynamics	MEEN 576 Propulsion
MEEN 500 Mech Engr Lab III	MEEN 577 Aero & Propulsion Lab
MEEN 564 Machine Design II	MEEN 422 Aero Veh Structures I
MEEN 566 Design of Thermal Sys	MEEN 578 Flight Veh Performance
MEEN 574 Mechanical Sys Design	MEEN 580 Aero Veh Design

In addition, the two technical electives in the program will be restricted to the following group of courses.

Aerospace Technical Electives

MEEN 651 Aero Vehicle Structures II
MEEN 652 Aero Vehicle Stability and Control
MEEN 653 Aero Vehicle Flight Dynamics
MEEN 654 Advanced Propulsion
MEEN 655 Computational Fluid Dynamics
MEEN 656 Boundary Layer Theory
ELEN 668 Automatic Control Theory

Course outlines in the standard ABET format for all of the above courses are included in an appendix at the end of this report.

Under this plan, students will take a total of nine courses that are unique to the aerospace option. These courses will provide a reasonably broad background in aerospace engineering, but are similar enough in basic content to the courses they replace so as not to impair the student's fundamental mechanical engineering training. Aerospace related courses begin in the second semester of the junior year while the first five semesters remain unchanged from the existing ME program. A copy of the recently revised mechanical engineering curriculum (effective fall '93) is also included at the end of this report for comparison.

One of the most critical ABET accreditation criteria is the requirement that all engineering programs must include a minimum of 16 credit hours of engineering design content including a capstone design course in the senior year. The proposed aerospace option curriculum outline presented below indicates design content credit hours in parentheses beside the course credit hour column. With some difficulty, 16 credits of design content were maintained in the program.

Phase-In Plan

It is important to note that the undergraduate aerospace option is still in the proposal stage. Both the curriculum outline and the new courses proposed for the option must go through a lengthy approval process involving the Department of Mechanical Engineering, the School of Engineering, the University Faculty Senate and the University Faculty Forum. This process, which normally requires an entire academic year, must be completed before information on the option can be included in the University Bulletin. Nevertheless, a phase-in plan has been implemented beginning with the current Fall '92 semester. This is possible since one of the courses currently exists (ELEN 410 Linear Systems and Control) and others can be offered on a temporary basis under a Special Topics course number. The phase-in time table is shown below.

Fall '92	Spring '93
ELEN 410 Linear Sys & Control	MEEN 544 Spec Top: Aerodynamics
MEEN 660 Spec Top: Comp Fluid Dyn	MEEN 544 Spec Top: Aero Veh Struc I
	ELEN 410 Linear Systems & Contrl
Fall '93	**Spring '94**
MEEN 576 Propulsion	MEEN 415 Aerodynamics
MEEN 578 Flight Veh Performance	MEEN 422 Aero Veh Structures I
MEEN 652 Aero Veh Stabil & Contrl	MEEN 577 Aero & Propulsion Lab
ELEN 668 Automatic Contrl Theory	MEEN 580 Aero Vehicle Design
	MEEN 651 Aero Veh Structures II
	MEEN 653 Aero Veh Flight Dyn

Under this plan, current first semester juniors can begin the option in Fall '92 and graduate under the option in May '94, assuming that the plan gains eventual approval from all requisite university committees.

There are currently two ME students enrolled in ELEN 410 -Linear Systems and Controls and 9 students enrolled in MEEN 660 Spec Topics: Computational Fluid Dynamics, including four undergraduates. The number of students who enter the option should increase significantly next year when it can be officially advertised and promoted through the University Bulletin and the Mechanical Engineering Undergraduate Handbook and new brochures to be created for this purpose.

Graduate Aerospace Option

Creation of an aerospace option under the Master of Science in Mechanical Engineering program is significantly less complicated than the undergraduate option since ABET accreditation issues are not involved.

The Mechanical Engineering Department currently offers a Master of Science degree program with specializations in the areas of 1) Energy and Thermo/Fluids, 2) Mechanics and Materials and 3) Design and Manufacturing. With the advent of the NASA Center of Research Excellence, we plan to add Aerospace as a fourth specialization. Five MEEN 600 level aerospace courses are being added to the curriculum offerings along with ELEN 668 - Automatic Control Theory. These courses will be open to both undergraduate and graduate students. Undergraduates can take them as technical electives (two required) and graduate students can take them as part of the eight courses required under the MSME thesis option. Graduate students will round out their programs with existing 600 and 700 level courses as listed later. The five new 600 level courses are the following:

MEEN 651 Aero Vehicle Structures II
MEEN 652 Aero Vehicle Stability and Control
MEEN 653 Aero Vehicle Flight Dynamics
MEEN 654 Advanced Propulsion
MEEN 655 Computational Fluid Dynamics

Existing graduate courses that complement the aerospace option are:

ELEN 668 Automatic Control Theory
MEEN 604 Intermediate Dynamics
MEEN 612 Modern Composite Materials
MEEN 616 Design by Finite Element Methods
MEEN 618 Numerical Analysis for Engineers
MEEN 626 Advanced Fluid Dynamics
MEEN 650 Mechanical Properties and Structure of Solids
MEEN 656 Boundary Layer Theory (currently MEEN 710)

MEEN 702 Continuum Mechanics
MEEN 704 Advanced Dynamics
MEEN 731 Conduction Heat Transfer
MEEN 732 Convection Heat Transfer
MEEN 733 Radiation Heat Transfer
MEEN 720 Advanced Classical Thermodynamics
MEEN 724 Irreversible Thermodynamics
MEEN 777 Thesis
MEEN 788 Research
MATH 651 Methods in Applied Mathematics I
MATH 652 Methods in Applied Mathematics II

The thesis option MSME degree requires 24 credit hours of course work (8 courses) and 6 credit hours of thesis. Students are required to include 6 hours of mathematics in their program which can be chosen from MEEN 618 and MATH 651 and 652. Two typical MS programs with an aerospace specialization might contain the following courses.

Typical Program of Study I	Typical Program of Study II
MATH 651 Meth in Appl Math I	MATH 651 Meth in Appl Math I
MEEN 618 Num Anal for Engrs	MATH 652 Meth in Appl Math II
MEEN 626 Advanced Fluid Dynamics	MEEN 604 Intermediate Dynamics
MEEN 656 Boundary Layer Theory	MEEN 612 Modern Composite Mater
MEEN 655 Computational Fluid Dyn	MEEN 652 Aero Veh Stabil & Contr
MEEN 654 Advanced Propulsion	MEEN 653 Aero Veh Flight Dyn
MEEN 732 Convec Heat Transfer	ELEN 668 Automatic Control Theory
MEEN 733 Radiat Heat Transfer	MEEN 704 Advanced Dynamics
MEEN 777 Thesis	MEEN 777 Thesis

The undergraduate aerospace option will provide a firm foundation for continuing study with aerospace specialization at the MS level. The graduate students in this option should be actively involved with the ongoing research of the center.

D. FACULTY AND STUDENT PARTICIPATION

Student Involvement

Two undergraduate students are currently supported under the educational component of NASA-CORE. These are Miss Shiryl White and Miss Kimberly Musgrave, both mechanical engineering juniors. Both students work 10 hours per week under the supervision of Dr. Craft. Miss White's efforts are split about equally between clerical and research activities. Her research work involves investigating possible finite element models

for orthotropic braids used in composite materials for aircraft and spacecraft applications. The purpose of the research is to develop better modeling techniques to determine global material properties.

Miss Musgrave is also doing both clerical and research work. Her research involves running a finite element computer model of a composite sandwich shell for varying cases of skin and core thickness to find a minimum weight composite structure with adequate strength characteristics for possible application as an aerobrake.

Two additional undergraduate students are currently supported by the Center to help develop laboratory tools. These two students are Miss Monica Smith and Mr. Jerry Hoggard. Miss Monica Smith is working with Dr. Lai to develop computer programs for NASP simulation. This includes the development of NASP plane model and the computation of flight dynamics. Mr. Hoggard's effort is to compute the optimal trajectory using the NASP plane model.

Organization and Staffing

Dr. William Craft, Chairman of Mechanical Engineering, heads the educational component of the Center. Other faculty involved with the educational component include Dr. David Klett, Undergraduate Program coordinator, and Dr. Hsin-Yi Lai, Center Director.

Mr. Kenneth Jones was hired as a new faculty member in support of the Educational Component. He has many years experience working in the aerospace area and is currently completing the requirements for the PhD in aerospace engineering from North Carolina State University. His research work is in CFD and experimental hypersonic flow and his expertise will be an important complement to the CFD efforts currently underway as part of the center and also in helping to develop new laboratories in Propulsion and Aerodynamics. Dr. Jones will teach the Aerodynamics course during Spring '92.

Other faculty involved in teaching aerospace courses this academic year include:

1. Dr. Suresh Chandra, Prof. of Mech. Engr. - Teaching Computational Fluid Dynamics, Fall '92
2. Dr. Abdollah Homaifar, Assoc. Prof. of Elec. Engr. - Teaching Linear Systems and Controls, Fall '92 and Spring '93
3. Dr. Shen, Adjunct Asst. Prof. of Mech. Engr. - Teaching Aero Vehicle Structures I, Spring '93

E. FINANCIAL REPORT AND DETAILED COURSE OUTLINES

Financial Report of the Educational Component

1110	Faculty Release Time:		
	D.E. Klett	July 23, 1992 - August 6, 1992	$4,653
		August 14, 1992 - December 31, 1992	$3,489
1450	Undergraduate Assistants:		
	Shiryl White	July 1, 1992 - August 14, 1992	$ 315
		August 15, 1992 - December 31, 1992	$ 630
	Kimberly Musgrave	September 3, 1992 - December 31, 1992	$ 525
1800	Fringes (July 23, 1992 - December 31, 1992)		$1,985
2302	Laboratory Supplies		$ 0
2601	Office Supplies		$ 300
2902	Other Supplies		$ 0
3100	Travel Expenses		
	(Trip to NASA Headquarters March, 1992 - W. J. Craft		$ 655
	(Trip to Anaheim, CA November 8 - 12, 1992 - D. E. Klett		$1,239
4801	Indirect Cost		$5,287
5302	Scientific Equipment		
	3 pc's		$9,320
	1 printer		$ 890
	3 tape backup units		$1,440
	1 Wind tunnel instrumentation unit		$87,400
	(drag, lift, velocity, 3 planes of moment measurements)		
Total Budget for 1992			$120,828

Detailed Course Outline

Course outlines in the standard ABET format for all of the aerospace courses are included in the next few pages of this report.

AEROSPACE OPTION IN MECHANICAL ENGINEERING (Effective Fall'93)

FALL SEMESTER Course	cr	SPRING SEMESTER Course	cr
		FRESHMAN YEAR	
ENGL 100 Ideas & Expres I	3	ENGL 101 Ideas & Expres II	3
HIST Elec	3	MATH 132 Calculus II	4
MATH 131 Calculus I	4	GEEN 102 Comp Prog for Engrs	2
GEEN 100 Intro. to Engineering	2	CHEM 101 Gen. Chem. I	3
GEEN 101 Intro. Engr Graphics	2	CHEM 111 Gen. Chem. I Lab	1
SOC SCI Elec	3	HISTORY Elective	3
		HEALTH/PE Elective	1
Total	17	Total	17
		SOPHOMORE YEAR	
PHYS 241 Gen. Phys. I	4	MEEN 210 Num Methods in ME	2
PHYS 251 Gen. Phys. I Lab	1	PHYS 242 Gen. Physics II	4
MATH 231 Calculus III	4	PHYS 252 Gen. Physics II Lab	1
ECON 300 Prin of Economics	3	MATH 331 Appl. Engr. Math I	3
MEEN 226 Manuf. Processes	2	MEEN 335 Statics	3
HUMANITIES Elective	1	MEEN 360 Materials Science	2
Total	17	MEEN 300 Mech Engr Lab I	2
		Total	17
		JUNIOR YEAR	
MATH 332 Appl. Engr. Math II	3	*ELEN 410 Linear Sys & Contrl	3
ELEN 200 Elec. Circuit Anal.	3	MEEN 440 Mechanism Des & Anal	3 (1.5)
ELEN 206 Circuits Lab	1	*MEEN 415 Aerodynamics	3 (0.5)
MEEN 336 Strength of Matrl.	3	*MEEN 422 Aero Veh Structures I	3 (1)
MEEN 337 Dynamics	3	MEEN 474 Engineering Design	3 (2)
MEEN 441 Thermodynamics I	3	MEEN 400 Mech Engr Lab II	1
HEALTH/PE ELECTIVE	1	Total	16
Total	17		
		SENIOR YEAR	
MEEN 560 Mod. Engr. Materials	3 (1)	MEEN 562 Heat Transfer	3 (1)
MEEN 565 Machine Design	3 (2)	MEEN 581 Mechanical Vibration	3 (1)
* MEEN 576 Propulsion	3 (1)	* MEEN 580 Aero Veh. Design	3 (3)
* MEEN 577 Aero & Propulsion Lab	1	* AEROSPACE Elective	3 (1)
* MEEN 578 Flight Veh. Perform.	3 (1)	HUMANITIES Elective	3
* AEROSPACE Elective	3	Total	15
Total	16	(Numbers in Parentheses Indicate Design Credits)	

TECHNICAL ELECTIVES	
* MEEN 651 Aero. Veh. Structures II	3 (1)
* MEEN 652 Aero. Veh. Stab. & Cont.	3 (1)
* MEEN 653 Aero. Veh. Flight Dyn.	3
* MEEN 654 Advanced Propulsion	3 (1)
* MEEN 655 Computation Fluid Dyn.	3
MEEN 656 Boundary Layer Theory	3
ELEN 668 Automatic Control Theory	3

CONTENT	
Engineering Design:	16
Engineering Science:	52
Math. and Basic Sci:	35
Humanities & Soc Sci:	18
Other:	11
Total Credit Hours:	132

ELEN 410 Linear Systems and Controls

Catalog Data: This course is designed to provide the student with techniques used in analyzing control systems. Introduction to control theory. This includes: control system modeling and representation, features of feedback control system, state space representation, time domain analysis, root locus, and design compensation.

Textbook: Automatic Control Systems by B. Kuo, Prentice-Hall, 6th Edition.

References: Analysis and Synthesis of Linear Control Systems, C.T. Chen, and Feedback Control of Dynamic Systems, Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini.

Coordinator: Abdollah Homaifar

Prerequisite: MATH 331 and ELEN 200.

Topics:

1. Laplace Transforms
2. Mathematical modeling of physical systems
3. Block diagram and signal flow graphs
4. State space characterization of systems
5. Time domain analysis
6. Stability of systems
7. Root locus techniques
8. Frequency domain analysis (Bode)
9. Control system design and performance prediction.
10. Applications: Airplane attitude control, satellite control, and antenna tracking.

Computer usage: The course uses the CC computer package to solve the state space problem, draw the root locus as well as Bode diagrams, and design the compensator.

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%

MEEN 415 Aerodynamics

Catalog Data: The course begins with the fundamentals of fluid statics and dynamics followed by an introduction to inviscid flow theory with applications to incompressible flows over airfoils, wings and flight vehicle configurations.

Textbook: J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill, 1984.

Coordinator: S. Chandra

Goals: The objectives are to provide fundamental knowledge of the equations of fluid flow and of incompressible flow aerodynamics. This knowledge should include the application of inviscid flow theory to obtain forces and moments on elementary lifting surfaces (airfoils and finite wings).

Prerequisites: MATH 231, MEEN 337

Prerequisite by Topic:

1. Differential Equations
2. Dynamics

Topics:

1. Fluid Properties
2. Concepts of Fluid Statics
3. Concepts of Fluid Dynamics
4. Flow Similarity
5. Introduction to Viscous Flow Concepts
6. Introduction to Inviscid Flow Theory
7. Thin Airfoil Theory
6. Circulation

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credit or 100%

MEEN 422 Aero Vehicle Structures

Catalog Data: This course covers the determination of typical flight and landing loads and methods of analysis and design of aircraft structures to be able to withstand expected loads.

Textbook: Introduction to Aerospace Structural Analysis, Allen/Cole, 1985

Coordinator: A. Kelkar

Goals: The purpose of this course is to develop the student's ability to determine typical flight loads, to select acceptable analysis methods, and to apply these methods to the analysis of flight structures.

Prerequisites: MEEN 336, MEEN 337, MATH 331

Prerequisites by Topic:

Dynamics
Strength of Materials
Vector Analysis

Topics:

1. Flight and landing loads
2. Review of solid mechanics
3. Advanced beam theory
4. Design considerations
5. Design Project

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 1.5 credits or 50%
Engineering Design: 1.5 credits or 50%

MEEN 576 Propulsion

Catalog Data: This introductory course to aero propulsion systems includes coverage of one-dimensional internal flow of compressible fluids, normal shock, flow with friction, and simple heat addition. The basic concepts are applied to air-breathing aircraft ropulsion systems.

Textbook: High and Peterson, Mechanics and Thermodynamics, Addison Wesley, 1965

Coordinator: D. E. Klett

Goals: The objective of this course is to provide the student with the concepts and tools necessary for the analysis and design of modern air-breathing propulsion systems. Analysis of the various system components as well as the overall Propulsion system are stressed.

Prerequisites: MEEN 415 and MEEN 441

Prerequisites by Topic:

Differential Equations
Thermodynamics
Aerodynamics

Topics:

1. Gas Mixtures
2. Isentropic Flow
3. Flow with Heat Addition
4. Flow with Friction
5. Gas Generator Systems
6. Turbo Jets
7. Turbo Fans
8. Ram Jets

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 2 credit or 66 2/3%
Engineering Design: 1 credit or 33 1/3%

MEEN 577 Aerodynamics and Propulsion Laboratory

Catalog Data: This is a laboratory course to provide experimental verification of concepts learned in MEEN 415 and MEEN 576. Experiments are performed that reinforce the concepts from the lecture courses including wind tunnel experiments and performance of a gas turbine engine.

Textbook: Class handouts

Coordinator: K. Jones

Goals: To provide hands-on experience associated with the concepts and laboratory tools of aircraft aerodynamics and propulsion systems. The characteristics of one-dimensional flow with friction and/or heat addition are determined. The effects of operating conditions on the performance of a simple gas turbine are studied.

Corequisite: MEEN 576

Prerequisites by Topic: Aerodynamics
Thermodynamics

Topics:

1. Temperature, pressure, velocity and mass flow measurements
2. Introduction to wind tunnel and data acquisition system
3. Measurement of turbulence factor
4. Measurement of pressure distribution over a circular cylinder
5. Measurement of pressure distribution over an airfoil
6. Measurement of lift, drag, and pitching moment on a wing
7. Unchoked isentropic flow
8. Choked isentropic flow
9. Supersonic flow and shock waves
10. One-dimensional flow with friction
11. One-dimensional flow with heat
12. Performance of a single shaft gas turbine

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 1 credit or 100%

MEEN 578 Flight Vehicle Performance

Catalog Data: This course provides an introduction to the performance analysis of aircraft. Aircraft performance in gliding, climbing, level, and turning flight are analyzed as well as calculation of vehicle take-off and landing distance, range and endurance.

Textbook: F.J. Hale, Introduction to Aircraft Performance, Selection, and Design, John Wiley & Sons, 1984

Coordinator: H. Y. Lai

Goals: The objective of this course is to familiarize the student with the basic concepts of aircraft performance.

Prerequisites: MATH 231, MEEN 337

Prerequisite by Topic:

Calculus
Differential Equations
Dynamics

Topics:

1. Aerodynamic Forces
2. Propulsion Systems
3. Propeller Theory
4. Gliding Performance
5. Climbing Perfomance
6. Level Flight
7. Turning Flight
8. Take Off and Landing

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 2 credits or 66 2/3%
Engineering Design: 1 credit or 33 1/3%

MEEN 580 Aerospace Vehicle Design

Catalog Data: This is the capstone design course for the Aerospace option. This course requires the synthesis of knowledge acquired in previous courses and the application of this knowledge to the design of a practical aerospace vehicle system.

Textbook: D. Stinton, The Design of the Airplane, Van Nostrand, 1983.

Coordinator: H. Y. Lai

Goals: The objective of this course is to provide aerospace option students with the opportunity to apply previously acquired knowledge, with the aid of modern software, to the design of an aerospace vehicle system.

Prerequisites: MEEN 415, MEEN 422, MEEN 474, MEEN 576, MEEN 578, ELEN 410

Prerequisite by Topic:

Aerodynamics
Flight Vehicle Performance
Controls
Engineering Design
Flight Vehicle Structural Analysis
Propulsion

Topics:

1. Weight and Balance
2. Power Plant Selection and Performance
3. Determination of Aerodynamic Loads
4. Vehicle Performance
5. Analysis of Static and Dynamic Stability and Control
6. System Synthesis
7. Construction and Components
8. Cost Analysis
9. Performance Testing

ABET category content as estimated by faculty member who prepared this course description:

Engineering Design 4 credits or 100%

MEEN 651 Aero Vehicle Structures II

Catalog Data: This course covers deflection of structures, indeterminate structures, fatigue analysis, and minimum weight design. Finite element methods and software are utilized.

Textbook: Introduction to Aerospace Structural Analysis, Allen/Cole, 1985

Coordinator: A. Kelkar

Goals: The purpose of this course is to develop the student's ability to perform structural analysis using finite element methods and software packages and to apply these methods to the design and analysis of flight structures.

Prerequisites: MEEN 422

Prerequisites by Topic:

Strength of Materials
Introductory Structural Analysis

Topics:

1. Work and energy principles
2. Deformation and force analysis
3. Fatigue analysis
4. Finite element methods
5. Finite element software
6. Design for minimum weight
7. Design project

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 2 credits or 66 2/3%
Engineering Design: 1 credit or 33 1/3%

MEEN 652 Aero Vehicle Stability and Control

Catalog Data: This course covers longitudal, directional and lateral static stability and control of aerospace vehicles. It also covers linearized dynamic analysis of the motion of a six degree-of-freedom flight vehicle in response to control inputs and disturbance through use of the transfer function concept, plus control of static and dynamic behavior by vehicle design (stability derivatives) and/or flight control systems.

Textbook: None (Instructor's Notes)

Coordinator: A. Homaifar

Goals: The objective of this course is to extend the student's basic concept regarding vehicle stability and control to the more difficult problems in this area, and to introduce the mathematical tools and techniques necessary for the analysis of vehicle stability and control.

Prerequisites: ELEN 410

Corequisites: MEEN 415, MEEN 422

Prerequisite by Topic:

Aerodynamics
Flight Dynamics
Control Theory

Topics:

1. Static Stability
2. Equations of motion for a rigid aircraft
3. Linearization of equations of motion
4. Linear system analysis
5. Longitudal dynamics
6. Lateral dynamics

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 2 credits or 66 2/3%
Engineering Design: 1 credit or 33 1/3%

MEEN 653 Aero Vehicle Flight Dynamics

Catalog Data: This course covers the basic dynamics of aerospace flight vehicles including orbital mechanics, interplanetary and ballistic trajectories, powered flight maneuvers and spacecraft stabilization.

Textbook: None (Instructor's notes and handouts)

Coordinator: H. Y. Lai

Goals: The objective of this course is to familiarize the student with the fundamental dynamic problems associated with space flight.

Prerequisites: MATH 332, MEEN 337, MEEN 422

Prerequisite by Topic:

Partial Differential Equations
Dynamics
Flight Vehicle Performance

Topics:

1. Two-body Orbital Mechanics
2. Interplanetary Trajectories
3. Ballistic Trajectories
4. Optimal Trajectory Shaping
5. Powered Flight Maneuvers
6. Atmospheric Entry
7. Spacecraft Stabilization

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%

MEEN 654 Advanced Propulsion

Catalog Data: This technical elective is a second course in propulsion. It covers the analysis and design of individual components and complete air-breathing propulsion systems including turbo fans, turbo jets, ram jets and chemical rockets.

Textbook: High and Peterson, Mechanics and Thermodynamics, Addison Wesley, 1965

Coordinator: H. Y. Lai

Goals: To provide the student with the concepts and tools necessary for the analysis and design of modern air-breathing systems. Analysis of the various system components as well as the overall propulsion system will be stressed.

Prerequisites: MEEN 576

Prerequisite by Topic:

Aerodynamics
Thermodynamics
Basic Propulsion

Topics:

1. Subsonic and supersonic burners
2. Combustion and afterburners
3. Compressors
4. Turbines
5. Propellors
6. Engine design and component matching
7. Chemical rockets

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 2 credit or 66 2/3%
Engineering Design: 1 credit or 33 1/3%

MEEN 655 Computational Fluid Dynamics

Catalog Data: This course provides an introduction to numerical methods for solving the exact equations of fluid dynamics. Finite difference methods are emphasized as applied to viscous and inviscid flows over bodies. Students are introduced to a modern CFD computer code.

Textbook: Computational Fluid Mechanics and Heat Transfer, Anderson, Tannehill and Pletcher, Hemishphere

Coordinator: S. Chandra

Goals: The objective of this course is to familiarize the student with modern numerical methods for solving the governing equations of fluid flow.

Prerequisites: MATH 332, MEEN 415 or 416

Prerequisite by Topic:

Partial Differential Equations
Fluid Mechanics or Aerodynamics

Topics:

1. Governing Equations
2. Finite difference representation
3. Stability Analysis
4. Boundary Conditions
5. Applications

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%

MEEN 656 Boundary Layer Theory

Catalog Data: This course covers the fundamentals of internal and external boundary layer flows. Exact solutions of the Navier-Stokes equations are developed for a few specialized cases. The approximate boundary layer methods are developed and applied to a variety of problems. Turbulent boundary layer flows are introduced.

Textbook: Boundary Layers, A.D. Young, AIAA

Coordinator: K. Jones

Goals: The objective of this course is to familiarize the student with the fundamentals of viscous laminar and turbulent boundary layer flows.

Prerequisites: MATH 332, MEEN 415 or 416

Prerequisite by Topic:

Partial Differential Equations
Fluid Mechanics or Aerodynamics

Topics:

1. Governing equations and theoretical foundations
2. Some basic solutions of steady laminar 2-D flows
3. Approximate methods of solution of steady 2-D laminar flows
4. Transition
5. Structure of attached turbulent boundary layers
6. Integral methods of drag prediction
7. Turbulence modeling

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%

ELEN 668 Automatic Control Theory

Catalog Data: The automatic control problem icludes the development of mathematical descriptions of a system, the specification of schemes to control the system, the prediction of system performance by analysis or simulation, and the possible iteration or repeating of these sequential steps until satisfactory actual system performance is predicted.

Textbook: Linear System Theory and Design, Chi-T Chen, Holt, Rinehart and Winston

Coordinator: Abdollah Homaifar

Prerequisite: ELEN-410 or equivalent.

Topics:

Study of state variable approach to control system analysis and design:

1. Control System Realization
2. Controllability
3. Observability
4. State Estimation
5. Stability
6. Controller Design
7. State Function approach to linear system synthesis.
8. Presentation of Linear Algebra tools required for above.

ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%