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History of the Department of Industrial and Systems Engineering at Lehigh University, 1924-2010

Mikell Groover

Lehigh University, mpg0@lehigh.edu

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History of the Department of Industrial and Systems
Engineering at Lehigh University
1924-2010

Mikell P. Groover
Professor Emeritus of Industrial and Systems Engineering
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Preface

From 1924 until 1949, the industrial engineering curriculum at Lehigh was an option in the Mechanical Engineering Department. The importance of the industrial engineering program was recognized in 1930 by renaming the department Mechanical Engineering and Industrial Engineering. In 1949, the Department of Industrial Engineering was established as an independent entity in the College of Engineering, separate from Mechanical Engineering. Its name remained the same until 1994, when it was renamed the Department of Industrial and Manufacturing Systems Engineering, based on a recommendation of Peter Likins, who was Lehigh's president at the time. Finally, in 2001, the department name was changed to Industrial and Systems Engineering, which remains its name to the time of this writing (2017).

From 1964 until 2010, the author of this history was a member of the department, first as a graduate student and then as a faculty member. I was therefore an active participant in the department's history for much of its existence. I retired from the university at the end of 2010 and was no longer involved in the day-to-day activities of the ISE Department. This is the reason I have elected to conclude this history in the year 2010.

Throughout the narrative, my own person appears occasionally. After all, most of what I remember about the evolution of the department is based on my own observations of events as they were happening. I was there. In these appearances, I refer to myself in the third person (as "Groover") rather than in the first person. This may take some getting used to by the reader, but all of the other historical and contemporary figures in the account are also presented in the third person. The objective is to achieve a writing style that treats all of the players in the story impartially.

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Acknowledgments

I would like to acknowledge the help of Ilhan Citak in the Lehigh University Library for providing me with access to a variety of historical documents in the Library's Special Collections. Almost all of the details about faculty appointments (e.g., dates, degrees) and curriculum in this history were based on these documents (see References). The history includes some information about support staff in the department, but I found that university records on staffing were either non-existent or difficult to access, and I am grateful to Kathy Rambo and Ed Force II for filling in many of the details in this category. I would also like to acknowledge the efforts of Tamas Terlaky, our department chair at time of writing, in proofreading the first draft of this history and making numerous helpful suggestions about its content. One of his suggestions was to include mention of faculty awards over the years in the narrative. To address this issue, I have added an Appendix that lists faculty and staff awards and honors. Finally, I appreciate Abby Barlok's help in obtaining some of the photos used in this chronicle.

Chapter 1 Origins of Industrial Engineering

The origins of industrial engineering can be traced to a movement called *scientific management*. It started in the late 1800s in the United States, and its central thesis was that work could be made more efficient and productive by analyzing it and properly designing the methods by which it is accomplished. Its principal focus was on human labor performed in industrial mills and factories. It was a time during which such work was rapidly transforming from handicraft techniques to reliance on machines. Yet many jobs were still based on manual methods, some of which involved the use of simple tools and implements. For example, material handling of bulk materials such as ore and pig iron required men working with shovels.

In addition, the late 1800s and early 1900s were a period during which several important consumer products were introduced, including sewing machines, bicycles, and automobiles. To meet the mass demand for these products, new methods of production were required that allowed them to be made in ever-increasing quantities. Thus, it was an era that witnessed the confluence of (1) the need for production methods that were fast and efficient and (2) the early application of science to analyze and design those production methods.

The scientific management movement consisted of several approaches that can be summarized as follows:

- *Motion study*. This approach focused on the work methods and motions used by human workers. The objective was to determine the “one best way” to perform a given task and to eliminate wasted motions.
- *Time study*. Once the best method was determined for a given task through motion study, a time standard was established using stopwatch time study. Time standards provided workers with an indication of what was expected of them in their tasks, and it provided management with a measure of how much work should be accomplished by each worker.
- *Worker incentive plans*. These included piece rate and similar incentive systems, in which workers were paid in proportion to the number of work units completed rather according to time on the job. The objective was to encourage workers to work faster; thus, incentive plans were intended to benefit workers as well as their employers.
- *Use of data collection*, experimentation, record keeping, and cost accounting in factory operations.
- *Extensive use of standards in industry*. These included standardized methods, time standards, standard tooling, and documentation of all procedures used in the factory.

These approaches were revolutionary and sometimes controversial at the time they were first introduced, but they have evolved and been improved to become fundamental tools in the modern practice of management.

Frederick Winslow Taylor. [2], [4], [7], [8], [10] The development of scientific management is largely attributed to the efforts of Frederick Winslow Taylor (1856-1915) in the 1880s at the Midvale Steel Company in Philadelphia. He was hired into the company as a machine shop worker and rose to be foreman of the department and chief engineer of the company. While he was foreman sometime between 1881 and 1883, he implemented time study at Midvale, ultimately coming to the conclusion that separating the given task into work elements, timing each element and then summing the times to obtain the standard was better than timing the entire task. This is because the study of each work element allows unproductive motions to be

identified and eliminated, resulting in a more efficient overall task. This is the way direct time study is performed today.

Midvale Steel Company was noted for producing high-quality steel components for products such as military artillery, steam turbines, and railroad locomotives. Many of these components required machining operations to complete them, so Midvale's machine shop was an important contributor to the success of the company. During his tenure as foreman, Taylor conducted a series of metal machining experiments in the shop that were directed at determining the effect of cutting speeds, feeds, and cutting tools on product quality and production time. These experiments resulted in significant productivity improvements for the company.

During his time of employment at Midvale, Taylor was a correspondence school student at Stevens Institute of Technology, earning a degree in mechanical engineering in 1883.

In 1889 Taylor left Midvale and held several management positions, finally becoming an independent management consultant from 1893 to 1901. One of his most important engagements was with the Bethlehem Iron Company¹ in Bethlehem, Pennsylvania between 1898 and 1901. A famous experiment he conducted at Bethlehem was concerned with shoveling pig iron (the iron product tapped from blast furnaces). Taylor thought that the methods used by workers to load pig iron from the storage yard into railway freight cars were not efficient. The workers required long rest breaks to recover from working so hard. They averaged 12.5 tons of pig iron per day and earned \$1.15 per day. Taylor proposed to one of the men that by using improved methods designed by Taylor, he could earn \$1.85 per day. The improvements consisted of better techniques in the way the pig iron was picked up, carried, and shoveled into the cars. Taylor also promised more frequent but shorter rest breaks. The worker accepted the challenge and was able to consistently load 45 tons of pig iron per day using the new methods. In subsequent writings and speeches, Taylor referred to the worker as "Schmidt", but his real name was Henry Noll.² An historical plaque on South Third Street in Bethlehem commemorates Noll's life. The plaque reads:

Henry Noll (1871-1925) The productivity of this Bethlehem Steel worker, referred to as "Schmidt" was key to Frederick W. Taylor's landmark book, "Principles of Scientific Management." Noll was credited with loading 45 tons of pig iron a day in 1899, to increase his day's pay to \$1.85.

In 1899 and 1900, Taylor and a colleague at Bethlehem Steel conducted a series of experiments concerning the effect of different heat treatments on existing tool steels of the period. The tool steels were subjected to higher treatment temperatures than were normally used at the time. This resulted in the production of a tool steel capable of greater hot hardness, which allowed cutting speeds to be used that were several times higher compared to other tool steels used at the time. Appropriately, the new steel was named *high-speed steel*.

Taylor presented and published much of his work on scientific management through the American Society of Mechanical Engineers. The publications include *Piece-Rate System* (1895),

¹ Bethlehem Iron Company was renamed Bethlehem Steel Company in 1899 and Bethlehem Steel Corporation in 1904.

² Taylor had dreamed up the name Schmidt. Henry Noll lived in South Bethlehem at 812 Laufer Street. In 1910 Taylor's detractors circulated a rumor that Schmidt had been overworked to death. In truth, Henry Noll lived on to the age of 54. He died in 1925.

Shop Management (1903), *On the Art of Cutting Metals* (1906), and *Principles of Scientific Management* (1911). Taylor was elected national president of ASME for the 1906-07 term.

Frederick W. Taylor was the principal pioneer, proponent, and practitioner of scientific management. He has been called the “father of scientific management” as well as other names, some of which are less than adulatory. In fact, scientific management is sometimes referred to as “Taylorism” in a not-so-flattering recognition of his importance in the movement. He has also been referred to as the “father of industrial engineering” because the principles and techniques of scientific management evolved into the field of industrial engineering.



Frederick W. Taylor

Other Pioneers in the Early Development of Industrial Engineering. Taylor was not the only person involved in the development of scientific management and related techniques associated with industrial engineering. Taylor had his disciples and there were contemporaries who also made significant contributions. Among these people are the following together with how they influenced the development of industrial engineering:

- *Henry L. Gantt* (1861-1919) was an engineer and consultant in the scientific management movement who invented a chart (called the *Gantt Chart*) for scheduling work. Today, the chart is used in production planning and control and in project management [2], [4].
- *Henry Ford* (1863-1947) founded the Ford Motor Company in 1903 and is credited with inventing the *moving assembly line* [4], [12], [15]. Closer to the truth is that the assembly line was developed by several of his engineers at Ford around 1913, and Henry was the sponsor of this development. In any case, the moving assembly line proved to be one of the most significant advances in mass production. It is not considered to be part of the scientific management movement.³ However, the line balancing problem (assigning tasks to workers at stations along the line) has been the object of industrial engineering research for many years.

³ In 1914 Frederick W. Taylor visited the Ford plant where the moving assembly line had been installed and commented to his hosts that they had used the principles of scientific management without the help of any of the experts. It turns out that Henry Ford and his colleagues were not familiar with scientific management and had developed the assembly line quite independently [15].

- *Frank B. Gilbreth* (1868-1924) is noted for his work in *motion study* and has been referred to as the “father of motion study”. Two of his important contributions were that (1) all manual work is composed of 17 basic motion elements which he called therbligs⁴ and (2) there is “one best method” to perform any given task. Much of his career was involved with the construction trades. His contributions to that industry include participation in the development of the bricklayer’s scaffold that could be adjusted in elevation to minimize the distances workers had to reach for and move bricks and mortar [4], [9].
- *Lillian M. Gilbreth* (1878-1972) married Frank Gilbreth in 1904 and founded with her husband the management consulting firm of Frank B. Gilbreth, Inc. in 1915. Although the firm specialized in time and motion study, her later work emphasized industrial psychology and human factors (also known as *ergonomics*). During her marriage she had 12 children⁵ and earned a doctorate in industrial psychology from Brown University in 1915. She survived her husband by 48 years⁶ and became very successful in her own right as an author, consultant, and professor. Among her many honors and achievements, she was the first female engineering professor at Purdue University (1935-1948), was awarded 23 honorary degrees, and was the first woman to be elected to the National Academy of Engineering in 1965. She has been called the “first lady of engineering” [2], [4], [13].



Lillian M. Gilbreth

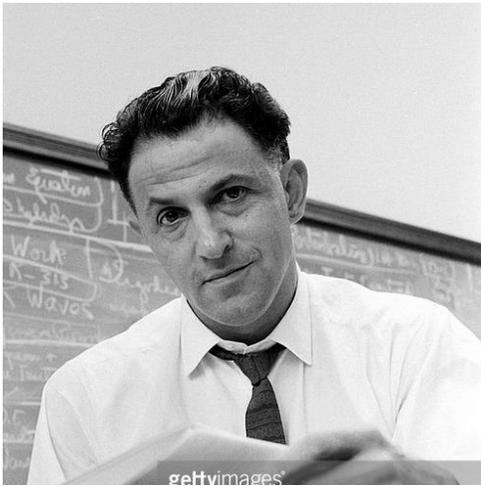
- *Walter A. Shewhart* (1891-1967) earned his doctorate in physics, but he is primarily recognized for his work as a statistician at the Hawthorne Works of Western Electric Company. He invented the *control chart* around 1924. This graphical technique is used in statistical process control to identify when a production (or other) process is operating normally (the process is experiencing only random variations) or abnormally (the process is experiencing variations that cannot be explained by random causes). Control charts are used in virtually all quality management systems (e.g., Total Quality Management, Six Sigma) and are included in quality control courses offered in most industrial engineering curricula [16].

⁴ Therblig is Gilbreth spelled backwards (well, almost).

⁵ The story of how Frank and Lillian Gilbreth practiced motion study and efficiency in their own household was published in 1949 by two of their children in the book *Cheaper by the Dozen*. The book was made into a movie in 1950.

⁶ Frank Gilbreth died of a heart attack at a railway station while talking on the telephone with his wife. He was 55.

- *Leonard H. C. Tippett* (1902-1985) was a statistician who studied the textile industry in England in the late 1920s. In one of the studies, he used a stopwatch to assess the durations of uptime and downtime on looms in the factory. The limitation of using a stopwatch was that he could only observe up to four looms at a time, and the survey needed to include all of the looms. As he was performing his study, one of the managers happened by and suggested he could tell which looms were working and which ones were down simply by observing the actions of the loom operator. If a loom was up and running, the operator just watched, but if the loom was down, the operator was bending over it to make repairs. It immediately became apparent to Tippett that all of the looms could be immediately classified as up or down by taking randomly scheduled periodic tours through the facility. Tippett had invented *work sampling*, a widely used tool in industrial engineering [4].
- *George B. Dantzig* (1914-2005) was a mathematician who is noted for his contributions in operations research, computer science, and other areas. He is probably most well-known for developing the *simplex algorithm*, a mathematical method for solving *linear programming* problems. Linear programming is a subset of a large universe of optimization problems called *mathematical programming*, which is included in nearly all industrial engineering curricula in the United States [11].
- *Richard E. Bellman* (1920-1984) was an applied mathematician who made important contributions in optimal control theory, including the development of a mathematical optimization method known as *dynamic programming*. He is also credited with coining the expression “the curse of dimensionality”, which refers to the exponential growth in the size of a mathematical problem as the number of variables in the problem increases. Dynamic programming is an operations research topic taught in most industrial engineering programs [14].



Richard E. Bellman

All of the topics identified above (time and motion study, work sampling, ergonomics, control charts, mathematical programming, etc.) have been or are currently subjects in nearly all college-level industrial engineering curricula.

Observations. The following observations can be made about the work and contributions of Frederick W. Taylor and others who followed him:

- Taylor conducted many of his experiments and developed many of his principles about scientific management while working at Bethlehem Steel Company, less than one mile from

the campus of Lehigh University. Yet, there is no record of Taylor ever interacting with any member of the Lehigh faculty or administration.

- Some people have speculated that Taylor Street, which follows a straight-line route from the former Bethlehem Steel works into the Lehigh campus, was named after Frederick W. Taylor. However, the streets in that area of South Bethlehem were mostly named after U.S. Presidents, and Taylor Street was named in honor of the 12th president, Zachary Taylor.
- Taylor and many of his associates in the scientific management movement were members of the American Society of Mechanical Engineers, and they presented and published their ideas through this forum. One must conclude that scientific management, out of which emerged the field of industrial engineering, was born of mechanical engineering.
- None of the contributors named above were industrial engineers. Taylor, Gantt, and the Gilbreths were associated with the scientific management movement, and industrial engineering had not been recognized as a separate branch of engineering at the time they began their work. Henry Ford was a businessman associated with the automobile industry who had neither knowledge nor care about scientific management. Shewhart, Tippett, Dantzig, and Bellman were statisticians and/or mathematicians.

Chapter 2 Lehigh University and IE: 1924–1949

Classes started for the first time at Lehigh University on September 1, 1866. Lehigh founder Asa Packer⁷ had donated \$500,000 and a plot of 60 acres to establish a “polytechnic college” in the borough of South Bethlehem. Forty students (all male) attended classes taught by six professors and two instructors. One of the professors, Henry Coppee, was also the president of the university. Lectures and recitations were held in the only classroom building on campus, Christmas Hall, which had been a church on Packer Avenue that was purchased and renovated by the university. On July 1 of the same year, the cornerstone had been laid for Packer Hall (now the University Center). This building was to become the main campus building, containing classrooms, lecture halls, the chapel⁸, and other rooms for various purposes.

The four-year curriculum consisted of uniform first and second years, followed by special schools in the third and fourth years. These special schools reflected the state of higher education at the time while emphasizing Mr. Packer’s desire to include technical training: (1) School of General Literature, (2) School of Civil Engineering, (3) School of Mechanical Engineering, (4) School of Mining and Metallurgy, and (5) School of Analytical Chemistry. Annual tuition was \$90 for years one and two and \$100 for years three and four.

In 1918, the academic organization of the university was restructured into three colleges: (1) College of Arts and Science, (2) College of Business, and (3) College of Engineering. The engineering college consisted of the following curricula: (1) Civil Engineering, (2) Mechanical Engineering, (3) Metallurgy, (4) Mining Engineering, (5) Electrical Engineering, (6) Chemistry, (7) Chemical Engineering, and (8) Ship Construction and Marine Transportation.

Industrial Engineering at Lehigh. The Pennsylvania State College (now Pennsylvania State University) was the first institution of higher education to establish a curriculum in industrial engineering. It was developed by Hugo Diemer in 1908 as an option in mechanical engineering. The program emphasized scientific management, foundry work, machining, woodworking, and other factory-oriented subjects. Other colleges and universities followed Penn State’s lead: University of Kansas in 1912, Columbia University and New York University in 1919, University of Pittsburgh in 1921, University of Alabama and Lafayette College in 1922, University of Michigan and Oklahoma A&M College (now Oklahoma State University) in 1924. By the end of the 1920s, a total of 15 undergraduate programs in industrial engineering had been started in the United States, including one at Lehigh [2].

In the 1924-1925 Lehigh University catalog, an industrial engineering course of study was announced: “The University has established a curriculum in Industrial Engineering, to be open to students entering the University in September, 1925. This curriculum is offered with a view to meeting the needs of students who desire the scientific and technical training offered by an engineering curriculum, but who intend to enter administrative or financial departments of industrial enterprises rather than the strictly technical ones and who wish, therefore, to supplement their engineering work with training in business administration and finance.”

⁷ Asa Packer (1805-1879) was an American industrialist who developed the Lehigh Valley Railroad. At one time, Packer was the third wealthiest man in the United States, according to the script presented during tours of his mansion in Jim Thorpe, Pennsylvania.

⁸ In 1885, the cornerstone for Packer Memorial Church was laid. This church would replace the chapel in Packer Hall. The chapel room would subsequently be repurposed as a drafting classroom and later as the faculty dining room, called the Asa Packer Dining Room.

The 1924-1925 catalog was not clear about whether the industrial engineering program was an option within mechanical engineering or was somehow a stand-alone program, albeit one without its own faculty. Later catalogs suggest that IE was an option within the ME Department.

The first year of the new IE program is the same as that of mechanical and electrical engineering curricula. The courses included algebra, geometry, chemistry, physics, mechanics, English, and a foreign language. Also required were short courses in military science, hygiene, and physical education. Attendance at chapel was mandatory. “The second year is given over primarily to engineering work,” but also included a two-course sequence in economics, and more coursework in military science, hygiene, and physical education. “The last two years are devoted in approximately equal proportions to engineering subjects and business subjects.” The listed engineering courses included alternating currents, electrical engineering, heat engines, dynamos and motors, and mechanism. Business courses included accounting, money and banking, industrial management, corporate finance, business law, and labor problems. There were no courses specifically designated as industrial engineering listed in the 1924-1925 catalog.

In the 1926-1927 University catalog, industrial engineering and the subjects covered were more completely defined: “Industrial Engineering has to do with the organization, operation and management of manufacturing plants, public utilities, and operating, holding and management companies. Broadly considered it covers the engineering aspects of plant location, plant layout, production control, maintenance, stores and inspection; the economic aspects of employment, employee training, promotion, wage payment, bonus, safety and welfare, insurance and old age pensions; and the commercial aspects of purchasing, marketing, credit accounting and finance.” As in the 1924-1925 and 1925-1926 catalogs, all of the courses listed in the program were borrowed from other programs in the engineering and business colleges. Thus the industrial engineering curriculum during these early years lacked its own identity and did not offer coursework that would later become intrinsic to the field of industrial engineering. Its appeal was its unique combination of a strong technical content plus subjects in business administration.

An important test of any new program offering is whether any students sign up for it, and if so, how many. In June 1927, there were two graduates who received the first Bachelor of Science degrees in industrial engineering. Given that the IE program had only begun in 1925, these two graduates must have started in one of the other programs (most likely ME) and then transferred to IE when it became available. There were 11 BSIE graduates in 1928, 16 in 1929⁹, and 13 in 1930. These numbers were greater than those of several of the other engineering programs such as engineering physics, metallurgical engineering, and mining engineering. The top engineering programs at Lehigh at that time were civil engineering and electrical engineering.

Industrial Engineering B.S. Program: 1930. The IE enrollment numbers were good enough to establish industrial engineering as a viable program for the University. The 1930-31 catalog was the first catalog to list “Mechanical Engineering and Industrial Engineering” as a single administrative unit. It was also the first catalog in which courses associated with industrial

⁹ The 16 BSIE graduates in 1929 included Edwin Hays Gott, who joined United States Steel in 1937 and became president and chief administrative officer (today the title is chief executive officer) in 1967. Mr. Gott was a member of the Lehigh Industrial Engineering Department’s Advisory Committee during the 1970s. The student-faculty lounge on the fourth floor of Mohler Lab is named in his honor. His son, Edwin Hays Gott, Jr., also attended Lehigh and was a fraternity brother of the author of this history during 1959-1962. Small world!

engineering were designated with an IE label. Together with (abbreviated) course descriptions, they were the following:

- IE 1. Industrial Employment (0 cr hr) Minimum of eight weeks of practical work.
- IE 2. Industrial Management (3 cr hr) The essential problems of organization, financial administration, plant layout, production control, and employment policies of industrial enterprises.
- IE 3. Industrial Management (3 cr hr) Continuation of IE 2.
- IE 4. Industrial Power (3 cr hr) Application of the principles of thermodynamics to the design and operation of steam power plants, internal combustion engines, compressors, and refrigeration.
- IE 5. Thesis (3 cr hr) Candidates for the BSIE degree may, upon approval, undertake a thesis as a portion of their work in the senior year.

IE 1 required a written report summarizing the work experience during the summer before the senior year. The other courses were taken by IE majors during their senior year, with IE 5 being an optional course. IE majors took no IE-labeled courses prior to their senior year.

In the 1934-1935 catalog, two new courses in psychology were added to the undergraduate industrial engineering curriculum: Psych. 1. Elementary Psychology (3 cr hr) and Psych. 15. Applied Psychology (3 cr hr). Two years later, Psych. 15 was renamed Industrial Psychology, which aligned it more closely with the industrial engineering curriculum.

Industrial Engineering M.S. Program: 1933. A Master of Science program in industrial engineering was announced for the first time in the 1933-34 catalog. A minimum of 30 credit hours was required. Candidates for the M.S. degree “may include in a major program graduate courses in engineering for which they have the necessary prerequisites.” Also, four mathematics courses and four psychology courses were listed for possible inclusion in the candidate’s program. The listed courses in mathematics were a two-course sequence in “Theory of Elasticity” (3 cr hr each) and a two-course sequence in “Aerodynamics” (3 cr hr each). And the listed courses in psychology were “Psychological Tests and Measurements,” (3 cr hr); a two-course sequence in “Seminar and Thesis in Psychology” (3 cr hr each); and “Systematic Psychology” (3 cr hr).

The description of the M.S.I.E. program continued: “The major must include a minimum of twelve hours of graduate courses in technical engineering, at least six of which must be in Industrial Engineering.” However, there were only two graduate courses (6 cr hr) available in the department, both taught by Prof. Fred V. Larkin, Head of the Department of Mechanical Engineering and Industrial Engineering, and Director of the Curricula in Mechanical Engineering and Industrial Engineering. Perhaps Prof. Larkin was anticipating that more courses would be added later, but for the time being there were only two courses. They were:

- IE 200. Management Policies (3 cr hr) Analysis of the factors that determine management policies. Discussion of organization, location, growth, size, socialization, and control of types of industries.
- IE 201. Personnel Policies (3 cr hr) Analysis of the factors that determine personnel policies. Discussion of the worker and his relation to industry, selection, health, training, safety, wages, welfare, and retirement.

Industrial Engineering B.S. Program: 1935. In the 1935-1936 academic year, several changes were made in the undergraduate curriculum. IE 2. Industrial Management, IE 3. Industrial Management, and IE 4. Industrial Power were replaced by the following four courses in the junior and senior years:

Junior year:

- IE 9. Industrial Engineering (3 cr hr) Engineering study of the principles governing the production plant, its location, buildings, layout, working conditions and maintenance.
- IE 10. Industrial Engineering (3 cr hr) Continuation of IE 9. Engineering study of the principles governing the production process, its organization, standardization and control.

Senior year:

- IE 11. Industrial Administration (3 cr hr) Management study of the industrial organization, its formation, duties, authority, responsibility and control.
- IE 12. Personnel Administration (3 cr hr) Management study of the personnel organization, its employment, training, safety and reward.

Changes in the 1939-1940 curriculum included the consolidation of IE 9 and IE 10 into a single course during the junior year:

- IE 13. Industrial Engineering (3 cr hr) A study of the engineering and economic problems arising in manufacturing industries.

Although the course description of IE 13 does not compare directly with the descriptions of IE 9 and IE 10, it seems fair to infer that the same topics were covered, perhaps at a more efficient pace. Also, two new courses were added to the 1941-1942 catalog: IE 121 and IE 122, both titled Experimental Industrial Engineering (3 cr hr each). These offerings were intended for students to perform “Experimental projects in selected fields of industrial engineering.”

World War II. In the late 1930s, enrollments at Lehigh were between 1800 and 1900 students. World War II started in Europe on September 1, 1939, when Germany invaded Poland. The United States remained neutral during the first few years, but the Japanese surprise attack on Pearl Harbor on December 7, 1941, brought the nation into the war as a full-fledged combatant. The war caused disruptions and hardships to many, both those in uniform and civilians back home. Lehigh was impacted significantly. The numbers in the table below, compiled from Lehigh University catalogs during the period, tell the story. Faculty staffing and student

Faculty and Students for the Years 1939 through 1948.

Academic Year	Total faculty	Faculty on leave	Remaining Faculty	Faculty in ME and IE	Total Students	Total IE Students	Total ME Students
1939-1940	173	1	172	13	1834	137	131
1940-1941	169	1	168	14	1770	163	213
1941-1942	177	2	175	15	1781	167	255
1942-1943	181	29	152	11	1780	164	316
1943-1944	178	36	142	11	472	10	119
1944-1945	159	70	89	4	339	17	76
1945-1946	177	36	141	6	674	51	136
1946-1947	222	7	215	15	2723	272	474
1947-1948	249	4	245	20	2961	306	464

enrollments remained fairly steady in the first few years of the war, but starting in 1942 the ranks of the faculty were depleted by those who were “absent on leave.” It must be assumed that the vast majority of them were serving their country in some way to support the war effort. The 1944-1945 catalog shows that 44% of the faculty was listed as on leave.

Student enrollment dropped by more than 80% between 1942 and 1944, with only 339 enrolled students listed in the 1944-1945 catalog for the Fall semester and 159 faculty members with 70 absent on leave. This resulted in attractive student-to-faculty ratios: 2.1 if all faculty members are counted in the calculation and 3.8 if only those remaining at Lehigh are figured into the ratio. However, the economics implied by those ratios were not attractive at all. Lehigh was struggling to survive. In response to these difficult times, the “University adopted [an] accelerated program as war-time emergency.”¹⁰ It initiated a 16-week summer session in the 1941-42 academic year to allow students to graduate in less than three years. “Research and science courses were offered in support of the war training program,” training for men in the Air Corps was started, and Lehigh “was made [a] key center for war information work.”

The Department of Mechanical Engineering and Industrial Engineering was especially stressed during the later war years. In the 1944-1945 University catalog, the number of teaching faculty at the rank of instructor and above was only four. A total of 39 ME courses and 10 IE courses were listed in the same catalog along with a total of 93 ME and IE students enrolled in all four years.¹¹

Following the war, total enrollments at Lehigh increased substantially, to levels above the prewar years, as indicated in the table. The numbers of faculty increased similarly, both in the University as a whole, and in the Department of Mechanical Engineering and Industrial Engineering. The 1946-47 catalog lists a total of 746 ME and IE students and the 1947-48 catalog lists 770. These numbers were greater than the totals in the entire College of Business Administration and the entire College of Arts and Science. It was time to start thinking about separating the Mechanical Engineering and Industrial Engineering Department into two independent departments.

Industrial Engineering B.S. Program: 1946. The 1946-1947 catalog introduced significant changes in the industrial engineering curriculum. Among the changes were the following: (1) IE 13. Elementary Industrial Engineering was moved from the junior year, second semester, to the sophomore year, first semester. (2) IE 111. Industrial Administration and IE 112. Personnel Administration were moved from the senior year to the junior year. (3) A total of six new senior elective courses were introduced, representing technical specialty subjects in industrial engineering. The new specialty courses were the following:

- IE 125. Production Control (3 cr hr)
- IE 126. Quality Control (3 cr hr)
- IE 127. Product Engineering (3 cr hr)
- IE 128. Work Simplification (3 cr hr)

¹⁰ All of these measures are listed in [6, p 34-37].

¹¹ Among the IE graduates in 1945 was Lido Anthony Iacocca, better known as Lee Iacocca. After graduating from Lehigh, he attended Princeton University, and then started his professional career at Ford Motor Company in 1946. He spearheaded the development of the Ford Mustang in the early 1960s and was named President of Ford in 1970. Personality clashes with Ford Chairman Henry Ford II resulted in Iacocca’s firing in 1978. He was later hired to lead Chrysler Corporation, finally retiring at the end of 1992 as President, CEO, and Chairman.

IE 129. Job Evaluation (3 cr hr)

IE 130. Industrial Relations (3 cr hr)

Seniors were required to select at least two of these electives in their senior years. The Lehigh IE curriculum was finally starting to look like a real industrial engineering program.

Chapter 3 Formation of The Industrial Engineering Department: 1949–1960

The separation of IE from the Mechanical Engineering Department occurred in 1949. The Department of Industrial Engineering was established as an independent entity at Lehigh, after 25 years of affiliation with ME. In the same academic year, a five-year curriculum in Industrial Engineering and Business Administration was announced, leading to a B.S. in IE at the end of four years and a B.S. in Business Administration at the end of the fifth year.

Thomas T. Holme was named Head and Curriculum Director of IE in 1949. He is listed as such in the 1950-51 University catalog. Holme had been hired in 1937 as an instructor in mechanical engineering. He had received his B.S. in ME in 1935 and his M.S. in ME in 1940, both degrees from Lehigh. In addition to Holme, who was promoted to full professor the same year that he became Head of the IE department, other department faculty listed in the 1950-51 catalog were Assistant Professors Gould and Beauchamp and Instructors Ramberg and Bastian.

A search of www.myheritage.com revealed that Holme was born in 1913 and died in 1993 with his last residence listed as Saint Helena Island, South Carolina. He only served as department head for a very short time¹², and his name does not appear in subsequent University catalogs. In the 1951-52 and 1952-53 catalogs, Milton C. Stuart, the Head of the Department of Mechanical Engineering, is listed as Acting Head of the Department of Industrial Engineering. In the 1953-54 catalog, Arthur F. Gould, Associate Professor of Industrial Engineering, was listed as IE Department Head (he had been appointed as head in 1952, but apparently too late for his new title to appear in the 1952-53 catalog). It turns out that Thomas Holmes left Lehigh in 1950 to become IE Department Head at Yale University, where he later earned his Ph.D.

Arthur Freeman Gould had been hired as an Instructor in Mechanical Engineering in 1947. He had received his S.B. from Massachusetts Institute of Technology in 1938 and had spent the intervening years in industry and the U.S. Army. He was promoted to assistant professor in 1948. He obtained his M.S. in mechanical engineering from Lehigh in 1949 and was



Industrial Engineering Department (circa late 1950s). Gould at extreme left, Richardson next to Gould, Kane at extreme right, others are unknown.

¹² Unfortunately, the 1949-1950 University Catalog is not among the catalogs in the Library's collection, so some details about Holme's tenure during this period are missing.

promoted to associate professor in 1951. He was promoted to full professor in 1953. He would remain as Department Head until 1967 and then Department Chairman until 1974. He then returned to the regular faculty as Professor and was appointed Associate Dean of Engineering and Physical Sciences. He retired in 1984 and died one year later.

In his tenure as Head and Chairman of IE, Gould was responsible for many of the developments that built industrial engineering at Lehigh into a highly-respected, nationally-ranked program. Improvements occurred in both the undergraduate and masters programs, and a doctoral program was launched during his tenure. Perhaps of greatest importance, he hired several faculty who would significantly enhance the department's reputation by their professional accomplishments.

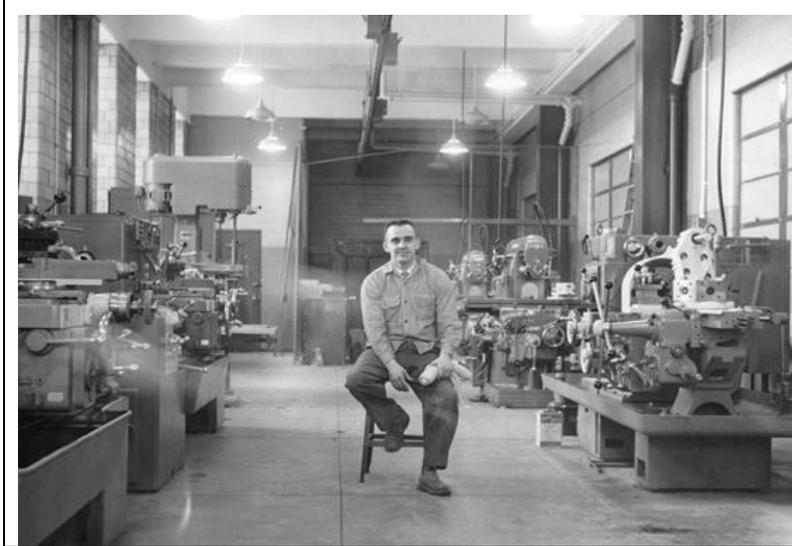
IE Faculty 1952 – 1960. At the start of Gould's tenure as department head in 1952, the industrial engineering faculty consisted of Stuart (still listed as Acting Head of IE in the 1952-53 catalog), associate professor Gould, assistant professors Heiland and Phillips, Instructor Kane, and graduate assistant Hughes. This was the starting team that Arthur Gould inherited. Of the six members, Stuart gave up his posts as Head of Mechanical Engineering and Acting Head of Industrial Engineering and returned to the regular faculty as Professor of Mechanical Engineering in 1952. He retired in 1957. Robert Heiland had been hired as an assistant professor in 1951, was promoted to associate professor in 1957, but left Lehigh around 1958 to become a full-time consultant. George Kane had started in 1950, but was on leave in 1952-53 to serve in the U.S. Navy during the Korean war. Finally, Frank Hughes and Sidney Phillips, who were both hired in 1951, had departed Lehigh by 1954.

Thus, George Kane was the only industrial engineering faculty member who had been with the department before Gould's promotion to IE Head and had stayed with the department during Gould's many years as leader.

George E. Kane served in the U.S. Navy during World War II, after which he returned to the states and earned a B.S. in industrial engineering from The Pennsylvania State University in 1948. Upon graduation he accepted a staff IE position at the Western Electric Company in Allentown. In 1950, he was hired as an instructor in the new Department of Industrial Engineering at Lehigh, where he simultaneously started graduate work towards an M.S.I.E. degree. He was recalled into the Navy during the Korean War and returned to Lehigh in 1953 to complete his M.S. in 1954. He was promoted from instructor to assistant professor in the same year, to associate professor in 1960, and full professor in 1964. He taught a variety of courses, but his specialty was manufacturing, in particular metal machining and the associated cutting tool technology. He established the Manufacturing Processes Laboratory in 1957 and 1958, which specialized in metal machining experiments for IE undergraduates and research for graduate students. IE 140 Manufacturing Processes Laboratory (1 cr hr) was introduced in 1958 as a required junior-level course in the IE curriculum.

Kane succeeded Gould to become Chairman of IE in 1974 and remained in that position until 1988. He became Associate Dean of the College of Engineering and Applied Science in 1988. In September 1989, he died in his sleep while attending a conference in Cincinnati, Ohio, at which he presented a seminar on metal machining. He had turned 64 years old six days earlier.

By 1960, Gould had hired Wallace J. Richardson (hired in 1952) as associate professor, Charles W. Brennan (1955) as assistant professor, William A. Smith, Jr. (1955) as instructor, and Sutton Monro (1959) as associate professor.



George E. Kane in the Manufacturing Processes Laboratory (circa 1959)

Wallace J. Richardson graduated from the U.S. Naval Academy in 1941. He served during World War II on destroyers and submarines in both the Atlantic and Pacific theatres. Medical problems forced him to retire from the Navy at the rank of Commander. He then launched a new career in industrial engineering, earning an M.S. degree from Purdue University in 1948 and studying under Dr. Lillian Gilbreth (Chapter 1). He then joined the Lehigh faculty as associate professor in 1952, and was promoted to full professor in 1959. Richardson's specialty was work methods and measurement, especially work sampling,¹³ and he was a successful independent consultant in these areas for many years.

Wally, as he was affectionately known to friends, colleagues, and even students, was devoted to undergraduate education and received two major University awards in recognition of that devotion. He is remembered by several generations of industrial engineering undergraduates for his ability to devise project assignments with too little data and not enough time. When the students would complain, he would reply, "This is what the real world is like."



Wallace J. Richardson (circa 1960)

¹³ He was co-author, with Lehigh colleague Robert Heiland, of one of the first books on the subject, titled *Work Sampling* (McGraw-Hill) published in 1957.

Among many admirable qualities, Richardson was guided by a strong moral compass. Ask him a question in which ethics was an issue, and he was immediately ready with the right answer. He also had the ability to summarize a given situation with an observation that was both witty and perceptive. On one occasion, when a university administrator made a pronouncement about something that was sure to happen, Wally quipped, “He’s always so sure of himself; not always right, but always sure.” Another time, he was asked to quote a price on a major project that was being considered. He answered, probably with a twinkle in his eye, “It will cost a lot of money, and that’s only an estimate.” Richardson retired from Lehigh in 1988 and passed away in 1989 at the age of 68.

Charles W. Brennan earned a B.S. from the University of Alabama in 1934 and an M.B.A. from the same school in 1952. Gould hired him into Lehigh in 1955 to teach personnel administration, wage and salary administration, and related courses. He became Assistant to the Dean of Engineering in 1958, Associate Dean of Engineering in 1960, and Dean of Students in 1964. He retired as Dean of Students around 1974.

William A. Smith, Jr., graduated from the U.S. Naval Academy in 1951. He served two tours on active duty in the Navy during the Korean War from 1951 to 1955. He was hired into Lehigh in 1955 as an instructor, while he pursued an M.S. degree in IE. He was awarded the degree in 1957 and promoted to assistant professor. He taught IE 110 Engineering Economy for many years, but his interests were focused on the emerging field of data processing and computer programming, and he taught IE 408 Data Processing. He was largely responsible for installing the first computer at Lehigh and starting a computer laboratory, which later evolved into the University Computer Center. He was promoted to associate professor in 1962, earned a Ph.D. from New York University in 1966, and was promoted to full professor in 1968. Smith left Lehigh in 1973 to become the IE Department Head at North Carolina State University at Raleigh. He later became President of the American Institute of Industrial Engineers.

Sutton Monro earned a B.S. from the Massachusetts Institute of Technology in 1942 and was hired by Gould in 1959 as associate professor in the department. Not much is known about the intervening years other than that he attended the University of North Carolina, Chapel Hill, during this period to pursue a Ph.D. in statistics. He was unsuccessful in that pursuit. The author’s understanding of the story is that his doctoral work was advised by a Prof. Robbins at North Carolina, and that Monro’s ongoing research resulted in the development of a new optimal search technique that was uniquely efficient. In his haste to exploit the finding, Robbins published a paper on the technique, calling it the “Robbins-Monro technique.” There was a rule at UNC at the time that prepublication of doctoral work rendered awarding of the degree impermissible. Monro never got his Ph.D. Gould hired him anyway, to teach courses in probability and statistics.

Industrial Engineering Support Staff. Few records were available to determine the names of the support staff during the early years after IE became a department (1949-1960). Most of the information on support staff in this chronicle is based on the recollections of people still around today (2017). Regarding office staff, those recollections begin in the 1960s (Chapter 4).

The first laboratory to be affiliated with the Industrial Engineering Department was the Manufacturing Processes Laboratory, established in 1957 and 1958 through the efforts of George Kane. The equipment in the lab consisted of machine tools for metal machining and associated cutting tools and metrology instruments. Kane hired the first technician to take care of the day-

to-day details of maintaining the equipment, ordering tools and materials, and so on: **Raymond Grund** was his name. So far as is known, he was an experienced machinist by trade and well-suited for the job. Ray was only there for about five years. He died in 1963.

Industrial Engineering B.S. Curriculum: 1952. The undergraduate IE curriculum underwent a major revision around 1952 that increased the number of industrial engineering credit hours required for graduation in IE from 15 in 1946 to 25.¹⁴ This was first announced in the 1952-1953 catalog, so the changes were probably initiated before Gould became head. The new curriculum was the following (only IE courses are listed):

Junior year:

IE 110. Engineering Economy (3 cr hr)

IE 114. Plant Administration (3 cr hr)

IE 115. Personnel Administration (3 cr hr)

IE 116. Plant Administration (3 cr hr) Continuation of IE 114.

Senior year:

IE 350. Industrial Engineering Problems (1 cr hr)

IE Electives (12 cr hr)

In addition to the increase in total credit hours required, the curriculum changes included the following:

- A new course in Engineering Economy (3 cr hr) in the junior year
- A new second course in Plant Administration to make a two-course sequence (3 cr hr each) in the junior year
- An increase from two to four IE elective courses (3 cr hr each) required in the senior year
- A new course IE 350 Industrial Engineering Problems (1 cr hr) in the senior year. The description read “Comprehensive study of problems encountered in manufacturing with special attention to organizational relationships and the interdependence of the various functions such as quality control, production control, product engineering, labor relations and cost control.”

To accommodate these additions, several business courses were removed in the senior year, IE 13 Elementary Industrial Engineering in the sophomore year and a course in engineering statistics in the junior year were dropped. The effect of these changes was to establish the IE program at Lehigh with its own identity, far different from the original IE curriculum in 1924 that had borrowed all of its courses from other departments.

Another change in the IE course line-up introduced in the 1952-53 catalog was the addition of a service course:

IE 162. Industrial Management (3 cr hr) Survey of topics in industrial engineering intended for majors other than IE. IE majors were not allowed.

¹⁴ It should be noted here that the course numbering system throughout the University was changed in 1951 to its current format, in which sophomore and junior courses could be renumbered as 100-level or 200-level, senior courses were renumbered as 300-level instead of 100-level, and graduate courses were renumbered as 400-level instead of 200-level. Thus, IE 2 Industrial Management became IE 102, IE 125 Production Control became IE 325, IE 200 Management Policies became IE 400, and so on.

In a sense, the industrial engineering program at Lehigh had come full circle, from relying entirely on service courses from other engineering disciplines to define its curriculum, to now offering a service course to other engineering majors.

Industrial Engineering M.S. Program: 1954. At the graduate level, three new courses were introduced at the 400-level in addition to the existing IE 400 Management Policies and IE 402 Personnel Policies:

IE 404. Special Topics in Industrial Engineering (3 cr hr)

IE 406. Advanced Methods and Time Study (3 cr hr)

IE 407. Operations Analysis and Control (3 cr hr)

These courses were initially announced in the 1954-1955 catalog. The last course in the list was the first course taught at Lehigh in what would become the very important field of operations research. The course description read as follows: “A study of planning and control activities in a manufacturing organization with emphasis on quantitative techniques of analysis.” The work of George Dantzig, Richard Bellman (Chapter 1), and other contributors is included within the scope of operations research, but the field was in its infancy by the time Prof. Gould started teaching IE 407 around 1954.¹⁵

Industrial Engineering B.S. Curriculum: 1960. The undergraduate IE curriculum in the 1960-1961 catalog increased the total number of IE required courses in the major from 25 in 1952 to 27. In the junior year, the program still listed IE 110. Engineering Economy (3 cr hr), IE 114. Plant Administration (3 cr hr), IE 115. Personnel Administration (3 cr hr), and IE 116. Plant Administration (3 cr hr), but a new laboratory course was added:

IE 140. Manufacturing Processes Laboratory (1 cr hr)

In the senior year, IE 350. Industrial Engineering Problems was still required but the number of credit hours had been increased from 1 to 2, and the course content had changed significantly. The description read (changes are in italics): “Comprehensive study of problems encountered in manufacturing with special attention to *quantitative methods of problem analysis including such topics as sampling controls, queueing theory, mathematical programming, probability theory, [and] design of experiments.*” Gould was introducing operations research into the undergraduate curriculum and making it a requirement in the senior year.

As in the 1952-53 catalog, a total of four IE 300-level Electives (12 cr hr) were still required, but the number of 300-level elective courses available for seniors to select from had increased from 6 to 8. They were:

IE 321. Experimental Industrial Engineering (3 cr hr)

IE 322. Experimental Industrial Engineering (3 cr hr)

IE 325. Production Control (3 cr hr)

IE 326. Quality Control (3 cr hr)

IE 328. Work Simplification (3 cr hr)

IE 329. Wage and Salary Administration (3 cr hr)

IE 330. Industrial Relations (3 cr hr)

¹⁵ The first textbooks in operations research were not published until the late 1950s. They included Churchman, Ackoff, and Arnoff: *Introduction to Operations Research* (Wiley, 1957); Morse: *Queues, Inventories, and Maintenance* (Wiley, 1958); Sasieni, Yaspan, and Friedman: *Operations Research* (Wiley, 1959). George Dantzig published *Linear Programming and Extensions* (Princeton U. Press) in 1963.

IE 340. Production Engineering (3 cr hr)

The (originally numbered) IE 127 Product Engineering had been replaced by IE 340 Production Engineering, and IE 129 Job Evaluation had been replaced by IE 329 Wage and Salary Administration.

Industrial Engineering M.S. Program: 1960. In the same 1960-61 catalog, the 400-level courses “For Graduates” were the following:

IE 400. Management Policies (3 cr hr)

IE 402. Personnel Policies (3 cr hr)

IE 405. Special Topics in Industrial Engineering (3 cr hr)

IE 406. Advanced Methods and Time Study (3 cr hr)

IE 407. Operations Analysis and Control (3 cr hr)

IE 408. Data Processing (3 cr hr)

IE 409. Industrial Engineering Standardization (3 cr hr)

This represented a substantial enhancement over the original course offerings when the graduate program was first announced in the 1933-34 catalog with only two courses: IE 200 Management Policies and IE 201 Personnel Policies (converted to IE 400 and IE 402, respectively, under Lehigh’s revised course-numbering system). Earlier IE graduate students were forced to fill out their 30-credit-hour M.S. requirement with many courses from other departments. Now they could take most of their 400-level coursework in their major department.

Chapter 4 The Arthur Gould Years: 1960–1974

Going into the 1960s, Art Gould had lead the development of a first-rate undergraduate program in industrial engineering and had assembled an outstanding faculty team consisting of ambitious and highly-motivated players, all committed to the success of the Industrial Engineering Department. There was just one problem. None of the players had a Ph.D. The IE Department was the only major academic department at Lehigh University in which not one of its faculty had a Ph.D. as his terminal degree. And it was the only department in the College of Engineering that did not offer a Ph.D. program. But how could it offer a Ph.D. program if none of the faculty had a Ph.D.?

Under Gould's leadership during the 1960s and early 1970s, the department hired several new faculty, increased its undergraduate and graduate course offerings, started a Ph.D. program, and initiated sponsored research. At the start of the 1960s, there were six faculty above the rank of instructor: Profs. Gould and Richardson, Associate Prof. Monro, and Assistant Profs. Brennan, Kane, and Smith. In addition, several instructors and graduate assistants were hired in the 1960s; they worked on their masters degrees but also had teaching responsibilities.



Arthur F. Gould (circa 1975)

New Faculty 1960-1965. New faculty added to the department during the early and mid-1960s were Narendra P. Loomba (hired in 1962), John M. Carroll (1964), John W. Adams (1965), and Gary E. Whitehouse (1965). Gould was attempting to improve the academic credentials of the department by either hiring Ph.D.s or growing them from within his faculty. William Smith and John Carroll represented the latter category. In the back of his mind was the goal of positioning the department to offer a Ph.D. program in IE.

Narendra P. Loomba was hired in 1962 as Associate Professor of Management and was promoted in 1963 to full professor. He shared a cross-appointment with Industrial Engineering and his name is listed among the IE faculty in the 1963-64 catalog. Two observations stand out: (1) He was the first member of the IE Department to hold a Ph.D., albeit his status was shared between IE and Management, and (2) he seemed to like being in school. His academic credentials included a B.S. from the University of Punjab (India) in 1947, a B.S. in EE and a B.S. in ME from the University of Nebraska in 1952, an M.S. in EE from the Massachusetts Institute of Technology in 1954, and a Ph.D. from the University of Wisconsin in 1959. That adds up to

about 16 years as a student in higher education. In 1967 he went "on leave" from Lehigh and never came back.

William A. Smith was encouraged to pursue a doctorate at New York University and for several years commuted back and forth between Lehigh and Manhattan, finally earning the Ph.D. from NYU in 1966.

John M. Carroll had earned a B.S. at Lehigh in 1950 and an M.A. at Hofstra University in 1955. He was hired as an associate professor of industrial engineering at Lehigh in 1964, while he pursued a Ph.D. at New York University. He received that degree in 1968. He was listed as "on leave" in the 1969-70 and 1970-71 catalogs, after which he is no longer listed among the faculty.

John W. Adams had earned a B.S. in chemical engineering from the University of Nebraska in 1952, served in the U.S. Army, and then earned a Ph.D. in statistics from University of North Carolina at Chapel Hill in 1962. Apparently Sutton Monro and Adams were acquaintances owing to their mutual affiliation with UNC, and Sutton alerted Arthur Gould that John might be available for hire into the department. Gould followed up on the tip and hired John in 1965 as an associate professor. John taught courses in probability and statistics, quality control, and operations research at the undergraduate and graduate levels. He retired in 1995, but continued to teach as an adjunct professor for about 10 more years.



John W. Adams (circa 1985)

Gary E. Whitehouse had received the B.S. and M.S. degrees in industrial engineering from Lehigh in 1960 and 1962, respectively. He desired to pursue a Ph.D. degree but the Department of Industrial Engineering at Lehigh did not offer that degree in 1962. He considered the possibility of studying for a Ph.D. in Mechanical Engineering at Lehigh, but the prerequisite ME courses that he would have had to take were overwhelming. Besides, he wanted a doctorate in industrial engineering, not mechanical engineering. He decided instead to apply to Arizona State University, where he was awarded the Ph.D. in 1966. Art Gould hired him at the start of the Fall Semester, 1965. He was a significant addition to the faculty in the area of operations research, which he had studied at ASU. When Whitehouse worked on his masters degree at Lehigh from 1960 to 1962, only one 400-level course related to OR was offered: IE 407 Operations Analysis and Control (3 cr hr). A 300-level course, IE 350 Industrial Engineering

Problems (3 cr hr), also included topics in operations research. Whitehouse's first textbook, *Systems Analysis and Design Using Network Techniques* (Prentice-Hall), was published in 1973.



Gary E. Whitehouse (circa 1970)

Industrial Engineering B.S. Curriculum: 1960. In the 1960-1961 catalog, the lineup of industrial engineering electives intended "For Advanced Undergraduates and Graduates" were the following:

- IE 321. Experimental Industrial Engineering (3 cr hr)
- IE 322. Experimental Industrial Engineering (3 cr hr)
- IE 325. Production Control (3 cr hr)
- IE 326. Quality Control (3 cr hr)
- IE 328. Work Simplification (3 cr hr)
- IE 329. Wage and Salary Administration (3 cr hr)
- IE 330. Industrial Relations (3 cr hr)
- IE 340. Production Engineering (3 cr hr)
- IE 350. Industrial Engineering Problems (3 cr hr)

IE 350 Industrial Engineering Problems was a new course which included topics such as "queueing theory, mathematical programming, probability theory, [and] design of experiments." It was a precursor to the subsequent offering of required courses in operations research.

Industrial Engineering M.S. Program: 1960. In the same 1960-61 catalog, the 400-level courses "For Graduates" were the following:

- IE 400. Management Policies (3 cr hr)
- IE 402. Personnel Policies (3 cr hr)
- IE 405. Special Topics in Industrial Engineering (3 cr hr)
- IE 406. Advanced Methods and Time Study (3 cr hr)
- IE 407. Operations Analysis and Control (3 cr hr)
- IE 408. Data Processing (3 cr hr)
- IE 409. Industrial Engineering Standardization (3 cr hr)

This represented a substantial enhancement over the original course offerings when the graduate program was first announced in the 1933-34 catalog with only two courses: IE. 200 Management Policies and IE. 201 Personnel Policies (converted to IE 400 and LE. 402, respectively, under Lehigh's revised course numbering system). Earlier IE graduate students were forced to fill out

their 30-credit-hour M.S. requirements with many courses from other departments. Now they could take most of their 400-level coursework in their major department.

Industrial Engineering Ph.D. Program: 1966. The Department of Industrial Engineering announced the start of its Ph.D. program in 1966. Four graduate students signed up to take the Qualifying Exam. Three passed. The fourth, with help from Art Gould, transferred to one of the mid-western state universities and earned his Ph.D. there. On October 12, 1969, the first two Ph.D. degrees in IE were awarded to Larry White and Mikell Groover. White did his research in information systems and finished his dissertation and other requirements with time to spare before the 1969 graduation deadline. Groover did his research in manufacturing and made the deadline by the skin of his chin. However, at the October 1969 graduation ceremony, the degrees in each discipline were awarded in alphabetical order, so Groover was the first Ph.D. awarded in IE at Lehigh. White received his degree about 12 seconds later. It is ironic that both Groover and White were undergraduate majors in disciplines other than IE. Groover was an ME, and White was an EE.

New Faculty: 1969-1974. During the remainder of Gould's tenure as Chairman of Industrial Engineering (until 1974), 13 Ph.D.s were awarded by the department and several of the graduates were hired as assistant professors. Mikell Groover was the first in 1969. Others included John Landis and Wayne Shiveley (1971), Lucius Riccio (1972), Emory Zimmers, Jr., (1973), and Ben Wechsler (1974). Art Gould had enhanced his faculty's credentials by hiring his own Ph.D. graduates. In the 1973-75 catalog, the IE department listed five full professors, two associate professors, three assistant professors, and four instructors, a total of 14 faculty, six of whom had Ph.D.s. When Gould started his term as department head in 1952, the total was six faculty, none with Ph.D.

Mikell P. Groover had received his B.A. in Arts and Science in 1961 and B.S. in Mechanical Engineering in 1962. He was then hired by Eastman Kodak Company in Rochester, New York, as a manufacturing engineer. In 1964, he returned to Lehigh for his M.S. degree in IE, working as a research assistant on one of George Kane's research grants. He earned his M.S. in 1966, and began working as an instructor while pursuing the Ph.D., which he was awarded in 1969, as previously noted. He was promoted to Assistant Professor in 1969, Associate Professor in 1973, and Professor in 1978. During a career of teaching and research at Lehigh,



Mikell P. Groover (circa 1972)

he made time to write textbooks on various topics in manufacturing and automation. He has published a total of eight titles, two of which were co-authored with IE faculty colleagues. Among the sole-author titles are *Automation, Production Systems, and Computer-Integrated Manufacturing*, now in its fourth edition (Pearson, 2015), and *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, now in its sixth edition (Wiley, 2016). Groover retired from Lehigh at the end of 2010, but he continues to try to improve his writing skills.

John D. Landis earned his B.S. and M.S. in IE from Lehigh in 1965 and 1967, respectively. He was awarded the Ph.D. from Lehigh in 1971 and was hired as assistant professor the same year. Landis was only at Lehigh about two years before going into industry through several positions, the last of which was vice president of manufacturing.

M. Wayne Shively received two B.S. degrees and one M.S. degree from the University of Missouri before coming to Lehigh as an instructor in 1968. He was awarded the Ph.D. from Lehigh in 1971 and promoted to assistant professor the same year. He stayed at Lehigh for about two years before accepting a position in the U.S. Government in Washington, D.C.

Lucius J. Riccio had earned his B.S. and M.S. in IE from Lehigh in 1969 and 1970, respectively. He was hired as assistant professor in 1972, and was awarded his Ph.D. in 1973. He left Lehigh after about three years to join the administration of New York City Mayor Abraham Beame. He remained in city government work for most of the rest of his career. In 1993, under Riccio's leadership, New York City's Office of Management and Budget received the INFORMS prize. In recent years, Riccio has taught at Columbia University in both the IEOR Department and the Business School.

Emory W. Zimmers, Jr., was a double major as an undergraduate, earning a B.S. in Mechanical Engineering in 1966 and a B.S. in Industrial Engineering in 1967. He was also awarded the M.S. in IE in 1967 and Ph.D. in 1973, whereupon he was hired as Assistant Professor. Early in his career, Zimmers taught courses in manufacturing, computers, and data processing, which prepared and encouraged him to establish the Computer-Aided



Emory W. Zimmers, Jr. (circa 1975)

Manufacturing (CAM) Laboratory in 1974. This lab was later renamed the Computer-Integrated Manufacturing (CIM) Laboratory and is now known as the Enterprise Systems Center (ESC) to reflect the much broader scope of its current operations. The ESC engages in research and projects in collaboration with industry. Zimmers is co-author with Mikell Groover of the book, *CAD/CAM: Computer-Aided Design and Manufacturing* (Prentice-Hall, 1984). It was the first textbook ever published on CAD/CAM.

In the early 1970s, Zimmers and Groover taught two sections of the introductory manufacturing course: IE 241 Fundamentals of Production Engineering (3 cr hr). Being the senior of the two, Groover was course leader, which meant he was responsible for deciding course content (within the limits of the course description). He accomplished this task by preparing detailed notes that were used to deliver the lectures in class. Groover would use the notes in his own section and then pass the notes to Zimmers to use in his section. Now here comes the amazing thing. At the end of the semester, Zimmers' student evaluations were often better than Groover's. Sometimes, life is not fair.

Ben L. Wechsler earned his B.S. at Carnegie Institute of Technology (now Carnegie-Mellon University) in 1942 and served in the infantry, U.S. Army, during World War II. He was awarded the Bronze Star Medal for "heroic conduct" in the Sicily campaign in July 1943. The citation reads in part that First Lieutenant Wechsler "distinguished himself by his courage, determination and excellent leadership in such an outstanding manner as to bring great credit on himself and the United States Airborne Forces." He remained in the service, earning an M.A. from George Washington University in 1962. In 1969, he was appointed Professor of Military Science and Chairman of the Department of Military Science at Lehigh University. He retired at the rank of Colonel and began work towards his Ph.D. in industrial engineering. He was awarded that degree in 1974 and appointed Assistant Professor in the department. He was promoted to Associate Professor in 1976. That same year, he and Gary Whitehouse co-authored the textbook: *Applied Operations Research: A Survey* (Prentice Hall, 1976). In 1978, he



IE Department (circa 1970). From left: E. Zimmers (grad student), U. Meyer (grad student), G. Whitehouse, in back (unknown), M. Groover, A. Gould, J. Adams, W. Richardson, W. Shively (grad student), J. Powers (grad student), S. Monro, G. Kane, W. Gewehr (grad student).

became Director of the University's Computer Center. Wechsler retired from Lehigh in 1982 and died in 1997 at the age of 75. He is interred at Arlington National Cemetery.

Industrial Engineering Support Staff. Following the death of Ray Grund in 1963, George Kane hired **Gilbert Zambelli** as technician in the Manufacturing Processes Laboratory. Gil had served in the U.S. Navy and worked as a machine tool operator at Bethlehem Steel Company. He had earned his apprentice certificate in machining while at Bethlehem. The 1960s and early 70s were a period during which several undergraduate courses related to manufacturing were introduced, and graduate research was conducted that required equipment in the manufacturing lab; Gil was responsible for supporting these activities. Zambelli worked in the Manufacturing Processes Laboratory from 1963 until 1979, at which time he returned to Bethlehem Steel as a production machinist.

Faith Newhall was hired as the IE Department secretary for the IE office by Art Gould in 1967. She was subsequently promoted to department coordinator as personal computers were introduced into office operations during the 1980s, and the need for pure secretarial support diminished. Faith became the visible face of the IE Department to students during her many years in the department, finally retiring at the end of 1993.

Marcia Mielnik was hired to assist Faith, again while Art Gould was IE chairman in the 1970s. Marcia had worked for Western Electric Company (part of AT&T) in Princeton, New Jersey, during the years when Lehigh offered an IE Master's program in the late 1960s and early 70s. Gould participated in that program, and had met Marcia as a result. Marcia resigned her IE Department position in 1977 and went to work part-time for Art Gould when he became Associate Dean of Engineering.

Industrial Engineering B.S. Curriculum: 1974. The industrial engineering undergraduate curriculum had come a long way since 1952. The required number of IE credit hours had increased from 25 to 38. The IE courses required for majors in the three years beyond the freshman year were the following (1973-1975 catalog):

Sophomore year:

- IE 5. Industrial Engineering Models (3 cr hr)
- IE 18. Information Processing Theory (3 cr hr)

Junior year:

- IE 101. Fundamentals of Manufacturing Engineering (4 cr hr)
- IE 102. Work Systems (3 cr hr)
- IE 205. Engineering Statistics (3 cr hr)
- IE 206. Operations Research Techniques (4 cr hr)

Senior year:

- IE 154. Senior Project (3 cr hr)
- 15 credit hours of 300-level IE electives selected from the following list:
 - IE 307. Information Systems Engineering (3 cr hr)
 - IE 309. Data Processing Systems (3 cr hr)
 - IE 310. File Structure and Processing (3 cr hr)
 - IE 311. Decision Processes (3 cr hr)
 - IE 321. Experimental Industrial Engineering (1-3 cr hr)
 - IE 322. Experimental Industrial Engineering (1-3 cr hr)
 - IE 325. Production Control (3 cr hr)

- IE 334. Organization Planning and Control (3 cr hr)
- IE 325. Sampling and Quality Control (3 cr hr)
- IE 336. Analysis of Experimental Data (3 cr hr)
- IE 340. Production Engineering (3 cr hr)
- IE 344. Metal Cutting Theory (3 cr hr)

Industrial Engineering Graduate Courses: 1974. The IE Department had also added significantly to the number of 400-level graduate offerings, which had been organized into "three areas of graduate study and research which are emphasized in the department": information systems, manufacturing engineering, and operations research. These three areas also corresponded to the research interests of the faculty at this time. The graduate courses listed in the 1973-1975 catalog were the following:

- IE 405. Special Topics in Industrial Engineering (3 cr hr)
- IE 408. (Acctg. 408) Management Information Systems (3 cr hr)
- IE 410. Design of Experiments (3 cr hr)
- IE 415. Manufacturing Management (3 cr hr)
- IE 416. Dynamic Programming (3 cr hr)
- IE 417. (Mgt. 417) Advanced Mathematical Programming (3 cr hr)
- IE 418. Simulation (3 cr hr)
- IE 425. Production Systems (3 cr hr)
- IE 426. Inventory Theory (3 cr hr)
- IE 427. Queueing Theory (3 cr hr)
- IE 428. Advanced Work Systems (3 cr hr)
- IE 429. Stochastic Processes for Engineers (3 cr hr)
- IE 430. (Mgt. 430) Management Science Project (3 cr hr)
- IE 431. Operations Research Seminar (3 cr hr)
- IE 433. Manufacturing Engineering Seminar (3 cr hr)
- IE 437. Information Systems Seminar (3 cr hr)
- IE 438. Real Time Information (3 cr hr)
- IE 440. Application of Automation (3 cr hr)
- IE 441. Network Modeling Techniques (3 cr r)
- IE 444. Design of Cutting Tools (3 cr hr)
- IE 450. Manufacturing Problems (3 cr hr)
- IE 461. Readings (1-3 cr hr)
- IE 490. Research Methods Seminar (3 cr hr)

The offerings in operations research were especially strong: IE 416, 417, 418, 426, 427, 429, 431, and 441, a total of eight courses. Except for IE 431, the term "operations research" did not even appear in the title or description of these courses. In 1954, only one course related to operations research was offered: IE 407 Operations Analysis and Control. In less than 20 years, operations research had become one of the main specialty areas in industrial engineering at Lehigh.¹⁶

M.S. in Management Science. In addition to masters and doctoral programs in industrial engineering, an interdisciplinary graduate program leading to the M.S. in Management Science was announced in the 1973-1975 catalog. It was offered jointly by the IE Department and the Department of Management in the College of Business and Economics and consisted of

¹⁶ This was true not only at Lehigh but in virtually every industrial engineering curriculum in the U.S.

courses from both departments. The program was appealing to engineering and science graduates who were seeking a technical graduate program related to business. Required courses included:

IE 418. Simulation (3 cr hr)

IE 334, Mgt. 321, or Mgt. 412. Organizational behavior and structure (3 cr hr)

IE 430. (Mgt. 430) Management Science Project (3 cr hr)

Quantitative methods (9 cr hr)

Functional area such as finance or accounting (6 cr hr)

Sponsored Research in IE. In the early and mid-1960s, sponsored research began under several faculty members in the department. Research had always been an important activity in the department, because a research thesis was a requirement for obtaining an M.S. degree in IE. But the projects were either self-sponsored (by the graduate students themselves) or by the department in the form of graduate assistantships. George Kane was the most successful in obtaining external funding for his research. He received several grants from the National Science Foundation to study cemented carbide cutting tools, one grant from Bethlehem Steel Company in machinability of steels, and one grant from the U. S. Army on metal machining. Mikell Groover was awarded two National Science Foundation research grants in the early 1970s, one related to measurement of cutting temperatures and the other on optimization of cutting conditions in machining.

Arthur Gould's Legacy. Arthur F. Gould stepped down from the chairman's post in 1974. He had served as manager of the IE department for 22 years, one of the longest leadership terms at Lehigh. He could look back with pride on his accomplishments in building the faculty and curriculum of the department into one of the highest-ranked in the nation. Whether he actually engaged in such retrospection is anyone's guess. If he did, he was not vocal about it. Gould was smart, self-confident, strong-minded, and savvy after years in the army and as department head and chairman. He had a low tolerance for fools, which created problems for Groover in the early years of their relationship. Gould remained in the department as Professor and was also appointed Associate Dean of the College of Engineering and Physical Sciences in 1974, serving in that position until 1983. He retired in June 1984 and passed away about a year later.

Two stories about personal episodes may help the reader appreciate the legacy of Arthur Gould. The first occurred in the Fall semester 1966. Groover had been hired as an instructor while he took courses to pursue his Ph.D. One day around the middle of the semester, it occurred to him that he had never actually registered for the courses. He went in to see Art Gould and humbly explained the situation. Art thought about it for a moment and then telephoned the Registrar, James Wagner, whom Art knew well. The near end of the conversation went something like this: "Jim, we have a young graduate student here who has been taking courses this semester. As far as I'm concerned, he's registered, but he forgot to fill out the paperwork at the beginning of the semester. Can you take care of this for us?"¹⁷ Based on the strength of Art's relationship with Jim, Jim fixed the problem, and significant penalties for late registration or perhaps even denial of registration were avoided.

The other episode was during the late 1970s. George Kane was department chairman by this

¹⁷ In those years, registering required filling out paperwork forms and submitting them to the Registrar, and Groover had neglected to do that.

time, and he had appointed a committee to review the undergraduate curriculum and propose any course changes that might be appropriate. Mikell Groover was chairman of the committee along with four other faculty, including Gould. At one of the meetings, two of the younger faculty got into a heated personal argument that was heading toward a physical altercation. Groover was in disbelief, trying to figure out how to control the situation. During a brief lull in the confrontation, Art Gould just started talking as if nothing was going on. He masterfully and artfully (tsk!) defused the situation and allowed the two tempers to cool. The meeting was adjourned shortly thereafter.

Chapter 5 The George Kane Years: 1974–1988

George Eugene Kane was appointed Department Chairman in 1974 and served in that capacity until 1988. He had started at Lehigh in 1950 as an instructor and rose through the ranks to become full professor in 1964. He was well-prepared by experience and personality to succeed Arthur Gould as department chair. The department at this time consisted of five full professors (Gould, Kane, Monro, Richardson, and Whitehouse), two associate professors (Adams, Groover), three assistant professors (Riccio, Wechsler, Zimmers), and one instructor, a total of 11 faculty.



George E. Kane (circa 1985)

In addition to faculty changes, the George Kane years witnessed a number of significant events at Lehigh in which several IE faculty members participated. These events included new programs in CAD/CAM and robotics around 1980 and the introduction of a new graduate program in Manufacturing Systems Engineering in 1984. Also included was the relocation of the IE Department offices and facilities from Packard Laboratory, its home for more than 60 years, to the newly renovated Harold S. Mohler Laboratory in 1988.

Faculty Changes 1973 – 1988. During this period, covering most of George Kane’s years as chairman, the IE department lost several prominent members of its faculty. William A. Smith resigned in 1973 (one year before George assumed the chairmanship) to become IE Department Chairman at North Carolina State University, Raleigh. Gary Whitehouse resigned from Lehigh in 1978 to accept the IE Department Chairmanship at University of Central Florida in Orlando. And Art Gould retired in 1984.

Whitehouse and Groover were active members of the American Institute of Industrial Engineers (AIIE, later its name was changed to Institute of Industrial Engineers, IIE, and more recently to the Institute of Industrial and Systems Engineers, IISE). They would enjoy seeing each other at the annual AIIE conferences. Whenever they got together, Whitehouse would give Groover the following advice: “Mike, whatever you do, don’t go into university administration.” Notwithstanding that advice, Gary advanced from department chair to become Dean of Engineering and then Provost at University of Central Florida, from which position he retired around 2009. Meanwhile, Groover followed the advice.

Between 1974 and 1988, the department hired 10 new faculty, most of whom made their careers at Lehigh.

Louis J. Plebani earned a B.S. in Physics from Lehigh in 1968, an M.S. from American University in 1972, and then a Ph.D. in IE from Lehigh in 1976. He was initially hired as an instructor in 1974, promoted to Assistant Professor in 1976 and to Associate Professor in 1982. Plebani's interests range widely and include operations research, microprocessor systems, database and web applications, information systems, and even metal cutting. He also loves golf and was the champion golfer at the Hellertown Country Club for several years.

Larry E. Long was a Sooner. He earned his B.S. in 1967, M.S. in 1971, and Ph.D. in 1974, all from the University of Oklahoma in industrial engineering. He was hired as Assistant Professor at Lehigh in 1976 and promoted to Associate Professor in 1980. His field of expertise is computers and information systems, and he wrote more than 20 books in this field, sometimes co-authoring with his wife Nancy. Titles include *Computers in Business* (1987) and *Computers Information Technology in Perspective* (2004). He abandoned a promising career at Lehigh in 1985 to devote full time to writing books.

George R. Wilson received his B.S. in 1971, M.S. in 1973, and Ph.D. in 1979, all in industrial engineering from the Pennsylvania State University. He was hired as Assistant Professor at Lehigh in 1978 and promoted to Associate Professor in 1984. Wilson's specialty areas are operations research and production control. He teaches several courses in these areas for the department at the undergraduate and graduate levels. He is a consultant for IBM Corporation in the area of resource allocation and management. Wilson was appointed Associate Chairman of the ISE Department in 2011.

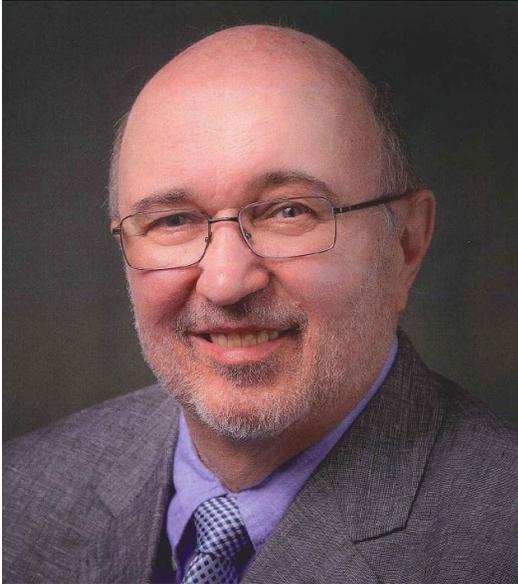


George R. Wilson (right) as ISE Department Associate Chair giving award to student (2011)

John R. Krobock was only at Lehigh from 1979 to 1982. He was hired at the level of Associate Professor. Krobock had received his B.S.E. from the U.S. Military Academy in 1953, served in the Army and then earned an M.S.E from Arizona State University in 1973.

Nicholas G. Odrey received a B.S. in 1964 and M.S. in 1966 in Aeronautical Engineering at the Pennsylvania State University and had spent several years working in the Aerospace Division of Goodyear Corporation. He returned to Penn State and earned his Ph.D. in Industrial Engineering in 1976. He had been a faculty member at University of Rhode Island and West Virginia University and was working at the National Institute of Science and Technology when

he was hired into Lehigh as Associate Professor in 1983. He was promoted to full professor in 1991. Nick did research and taught in the areas of manufacturing processes, automation, and robotics, and was Director of the ISE Robotics and Automation Laboratory. Odrey was co-author of *Industrial Robotics: Technology, Programming, and Applications* (McGraw-Hill, 1986) with Mikell Groover, Mitchell Weiss, and Roger Nagel.¹⁸ Odrey passed away in August 2013 at the age of 71.



Nicholas G. Odrey (circa 2000)

John C. Wiginton earned his B.A.Sc. in 1957 and M.B.A. in 1966 at University of British Columbia (Canada) and his M.S. in 1969 and Ph.D. in 1970 at Carnegie-Mellon University. He was hired into the department at the level of Professor in 1983 and became the lead person for the department's information systems thrust following the departure of Larry Long. John remained with the department for about ten years, taking early retirement in 1994.

Guruswami Sathyanarayanan came to the department with a Ph.D. in Mechanical Engineering from Michigan Technological University in 1984. He was hired as an Assistant Professor of Industrial Engineering at Lehigh the same year. He had earned his B.S. in ME in 1975 at University of Madras (India) and his M. Tech. in 1977 at Indian Institute of Technology (Madras). Sathya, as he preferred to be called, did most of his research in metal machining, specializing in grinding and nontraditional processes. He taught courses related to manufacturing at the undergraduate and graduate levels. He died in 2000 at the age of 46 while on sabbatical leave in India.

In his final two years as department chair, George Kane recruited three young faculty members just beginning their careers in academia. He was especially proud of these new hires at the end of his term as chair. His pride was well-founded. Regrettably, he did not live to see their professional achievements.

Robert H. Storer earned the B.S.E. in Industrial and Operations Engineering from the University of Michigan in 1979. He worked in industry for two years at General Dynamics in San Diego, California, before matriculating to Georgia Institute of Technology to earn an M.S. in

¹⁸ Mitchell Weiss was co-founder of United States Robotics, a company that produced industrial robots. Roger Nagel was Professor of Computer Science and Electrical Engineering at Lehigh.

1982 and Ph.D. in 1987 in operations research. Storer was hired as an instructor at Lehigh in 1986, promoted to Assistant Professor in 1987, Associate Professor in 1993, and Professor in 1999. His teaching and research interests include financial engineering, mathematical optimization, simulation, statistics, stochastic processes, and health care systems engineering. He is the Co-Director of Lehigh's Integrated Business and Engineering Honors Program.



Robert H. Storer (2011)

Gregory L. Tonkay had attended the U.S. Naval Academy for two years before transferring to the Pennsylvania State University, where he earned his B.S. in Industrial Engineering in 1981 and Ph.D. in 1987. He was hired as an instructor at Lehigh in 1986 and promoted to Assistant Professor upon receiving his doctorate. He was promoted to Associate Professor in 1993. Tonkay's teaching and research interests cover a wide range of technical areas, including manufacturing processes, industrial control systems, automation, databases and networking. He served as Associate Chairman of the ISE Department from 1998 through 2011 and Interim Chairman of ISE during the academic year 2007-2008. In 2011, Tonkay was appointed Associate Dean for Undergraduate Studies in the P. C. Rossin College of Engineering and Applied Science.



Gregory L. Tonkay (2011)

Szu-Yung David Wu received his B.S. in Industrial Engineering in 1981 from Tunghai University (Taiwan) and his M.S. and Ph.D. from the Pennsylvania State University in 1985 and 1987, respectively. He was hired as Assistant Professor in 1987, promoted to Associate Professor

in 1992, and Professor in 1998. During his career in the department, David was an outstanding researcher and taught courses in information systems and supply chain management. He was appointed Department Chairman of IE in 1998 and Dean of the P. C. Rossin College of Engineering and Applied Science in 2004. He retired from Lehigh in 2015 and became Provost and Executive Vice President at George Mason University, one of the three state universities in Virginia.



IE Department (circa 1980). From left: E. Zimmers, B. Wechsler, J. Adams, G. Wilson, A. Gould, L. Long, A. Kreutzer, J. Krobock, M. Groover, L. Plebani, G. Kane, W. Richardson, S. Monro.

Industrial Engineering Support Staff. In 1978, George Kane appointed Mikell Groover as Director of the Manufacturing Processes Lab. Gil Zambelli had been the laboratory technician since 1963. In 1979, he resigned his position to become a production machinist at Bethlehem Steel. Groover hired **Herb Ketcham** to replace Gil as technician in the lab. It was a period during which industrial robotics was being introduced in the laboratory. Thus, in addition to responsibilities in machining, Herb had to learn the new robotics technology: installing, programming, and maintaining robots that were brought into the lab. He did this with exceptional skill. Unfortunately, Herb left Lehigh in 1983. He was soon replaced by **Dan Holler**, a young man who had worked as a laboratory technician at the University of Pennsylvania. Dan's arrival coincided with the introduction of numerical control (NC) technology in the manufacturing lab. He showed great promise in learning the new technology. Sadly, Dan was killed in a motorcycle accident in Spring 1985.

At around the same time, Bethlehem Steel was in the process of downsizing operations at its Bethlehem plant, and Gil Zambelli was one of many workers who were laid off. The timing of Dan Holler's unfortunate passing and Gil's layoff from Bethlehem Steel were such that Groover was able to immediately hire Gil as Dan's replacement. Gil served the department with distinction during 1987 and 1988 when the Manufacturing Processes Lab was moved from Packard Lab into the Mohler Laboratory building. Gil supervised the day-to-day issues of

moving heavy machine tools and other equipment from their former location in Packard and installing them in a much larger space in Mohler. In addition, new machine tools and material handling equipment were acquired for the lab during his term as technician. The name of the lab was changed to the Manufacturing Technology Laboratory in 1988 to reflect the broader scope of technologies included in its activities. Gil remained as technician until his retirement in 1991. His official retirement date from Lehigh was 1993. He passed away in 2009 at the age of 80.

Back in the Industrial Engineering Department office, Faith Newhall was the office coordinator and Marcia Mielnik was her assistant. In 1977, Marcia resigned her position. **Carol Nemchik**, fresh out of high school, was hired to replace Marcia. Carol spent only about one year with the department, resigning to pursue other career interests. **Kathy G. Rambo**, also a recent high school graduate, was hired in 1978 to fill Carol's position. She would remain as administrative assistant to Faith until Faith's retirement, and was promoted to the position of department coordinator at the beginning of 1994. Kathy became the face of the Industrial Engineering Department to undergraduate students, just as Faith had been for the preceding 25 years.

CAD/CAM Program. The CAD/CAM Program at Lehigh was started in the IE Department with a single computer graphics terminal in the early 1970s. It was located in a small section of the Manufacturing Processes Laboratory. In 1974, the IE Department formed the Computer-Aided Manufacturing Laboratory with Emory Zimmers as Director. By around 1979, the Department of Mechanical Engineering and Mechanics had become interested in computer-aided design. A CAD/CAM task force was formed that included Zimmers, George Kane, Doug Abbott, Chairman of the ME Department, and John Ochs, a new assistant professor in ME who had used computer graphics in his doctoral research.

The group also included a member of Lehigh's Development Office, Michael Bolton. One of the important activities of the task force was to visit companies to solicit their participation and support to develop Lehigh's CAD/CAM Program. Bolton proved particularly effective at making the right contacts and arranging the company visits. The result of the task force's efforts was a multimillion dollar development that provided some of the finest university CAD/CAM facilities in the country.



Emory W. Zimmers (right) at lunch with Chrysler Chairman Lee Iacocca (class of 1945) during the campaign to develop Lehigh's CAD/CAM Program (circa 1985)

Robotics Institute. Lehigh's robotics program also had its beginnings in the IE Department. Mikell Groover had developed an interest in robotics while writing a textbook on automation in the late 1970s and through a consulting assignment around the same time. In 1981, he and Emory

Zimmers drove up to Schenectady, New York, to General Electric Company's Robotics Laboratory to seek advice on how to proceed with the development of a robotics program at Lehigh. Subsequently, a proposal was submitted to the Bethlehem Steel Corporation to fund the purchase of a Unimate PUMA¹⁹ robot from Unimation Inc. In 1982, the University established a Robotics Institute and hired Roger N. Nagel to be Director of the Institute.



Lehigh's first industrial robot, a Unimate PUMA, in the Manufacturing Processes Lab. Technician Herb Ketcham in center of photo, Mikell Groover at right, IE student at lower left, and two Bethlehem Steel executives at upper left (circa 1982)

Manufacturing Systems Engineering Masters Program. The Manufacturing Systems Engineering (MSE) Program was inaugurated at Lehigh in January 1984. Lehigh had been awarded a \$2,000,000 grant from IBM Corporation to design and offer a graduate program in MSE. Similar grants were awarded to four other schools out of more than 100 proposals submitted to IBM from across the United States. The other awardees were Georgia Institute of Technology, Rensselaer Polytechnic Institute, Stanford University, and University of Wisconsin at Madison. Lehigh's successful proposal was prepared by a committee chaired by Roger Nagel, Professor of Computer Science and Electrical Engineering (CSEE), and included representatives from Industrial Engineering, Mechanical Engineering, and the Department of Management and Marketing in the College of Business and Economics. Program participants from the IE Department were Mikell Groover, Nicholas Odrey, George Wilson, and Emory Zimmers. The Lehigh MSE Program was the very first winner in 1985 of the Society of Manufacturing Engineers LEAD Award for "Leadership and Excellence in the Application and Development" of computer-integrated manufacturing.

New Facilities for IE. Located directly across Brodhead Avenue from the Lehigh campus was the B'rith Sholem Community Center and synagogue. The University purchased the facility in 1984 with plans to renovate the four story building and locate several academic programs and classrooms there. By 1988, the renovations were nearly completed. The IE Department moved into the building in January 1988, joining the Manufacturing Systems Engineering Program, and the Robotics Institute. Initially called "Packard Lab West," it was formally named the Harold S. Mohler Laboratory, after the former Lehigh IE alumnus and chairman of the Lehigh Board of

¹⁹ PUMA is an acronym for Programmable Universal Machine for Assembly. It is a robot designed to perform assembly tasks.

Trustees.²⁰ The building also housed five classrooms and teaching labs, the Computer-Integrated Manufacturing Laboratory, the Manufacturing Technology Laboratory (formerly Manufacturing Processes Lab), and the Robotics Institute.

Industrial Engineering B.S. Curriculum: 1988. The undergraduate curriculum in industrial engineering in the 1988-1989 university catalog had grown from 38 to 43 required credit hours compared to 1974. The required courses in the major were (only the IE courses are listed):

Sophomore year:

- IE 111. Engineering Probability and Statistics (3 cr hr)
- IE 112. Computer Graphics (1 cr hr)
- IE 121. Applied Engineering Statistics (3 cr hr)
- IE 122. Software Tools (1 cr hr)
- IE 124. Engineering Economy and Decision Analysis (3 cr hr)

Junior year:

- IE 115. Fundamentals of Modern Manufacturing (3 cr hr)
- IE 116. Manufacturing Laboratory (1 cr hr)
- IE 131. Work Systems and Facilities Planning (3 cr hr)
- IE 132. Work Systems and Facilities Planning Laboratory (1 cr hr)
- IE 221. Operations Research – Probabilistic Models (3 cr hr)
- IE 222. Operations Research – Deterministic Models (3 cr hr)
- IE 224. Information Systems Analysis and Design (3 cr hr)

Senior year:

- IE 154. Senior Project (3 cr hr)
- IE 251. Production and Inventory Control (3 cr hr)
- IE 300-level Electives (9 cr hr)

New 300-level electives had been added since the 1973-1975 catalog:

- IE 305. Simulation (3 cr hr)
- IE 317. Probabilistic Models II (3 cr hr)
- IE 318. Deterministic Models II (3 cr hr)
- IE 332. Product Quality (3 cr hr)
- IE 341. Data Communication Systems Analysis and Design (3 cr hr)
- IE 342. Computer Integrated Manufacturing (3 cr hr)
- IE 343. Microprocessor Systems in IE (3 cr hr)
- IE 345. Manufacturing Information Systems (3 cr hr)

Course titles were changed for three courses relative to the 1973-1975 catalog:

- IE 307. Advanced Systems Analysis and Design (3 cr hr) formerly Information Systems Engineering
- IE 309. Introduction to Information Systems (3 cr hr) formerly Data Processing Systems
- IE 310. Database Analysis and Design (3 cr hr) formerly File Structure and Processing

Four 300-level courses that were in the 1973-1975 catalog had been dropped by 1988:

²⁰ Harold S. Mohler graduated from Lehigh in 1948 with a B.S. in industrial engineering. He joined Hershey Foods the same year and advanced to become president and chairman of the board of directors of the company until retiring in 1984. He was also elected to the Lehigh University board of trustees in 1971 and served as its chairman from 1973 to 1985. He died in 1988, shortly after Mohler Lab was dedicated in his honor.

- IE 311. Decision Processes (3 cr hr)
- IE 325. Production Control (3 cr hr)
- IE 335. Sampling and Quality Control (3 cr hr)
- IE 336. Analysis of Experimental Data (3 cr hr)

These undergraduate curriculum changes between 1974 and 1988 reflected an increased emphasis on operations research and a changeover of previous 300-level elective course material into required course material below the 300-level.

Industrial Engineering Graduate Programs. At the graduate level, a new graduate program had been introduced in 1973 in the Industrial Engineering Department: M.S. in Management Science. It was an interdisciplinary program administered jointly by the IE Department and the College of Business and Economics. And then there was the graduate program in Manufacturing Systems Engineering, which had been started in 1984 and to which the IE department contributed significantly.

New 400-level electives that had been added since the 1973-1975 catalog were the following:

- IE 409. Data Dependent Systems (3)
- IE 411. Networks and Graphs (3)
- IE 419. Sequencing and Scheduling (3)
- IE 424. Robotic Systems and Applications (3)
- IE 429. Artificial Intelligence in Manufacturing (3)
- IE 439. Applications of Stochastic Processes (3)
- IE 443. Automation and Production Systems (3)
- IE 449. Advanced Computer-Aided Manufacturing (3)

Course titles were changed for two courses relative to the 1973-1975 catalog:

- IE 437 Advanced Database Analysis and Design (3) formerly Information Systems Seminar
- IE 438 Advanced Data Communication Systems Analysis and Design (3) formerly Real Time Information

And five 400-level courses that were in the 1973-1975 catalog had been dropped by 1988:

- IE 418. Simulation (3)
- IE 425. Production Systems (3)
- IE 426. Inventory Theory (3)
- IE 427. Queueing Theory (3)

Some explanations about these dropped courses might be helpful. IE 418 Simulation migrated to the 300-level as an elective course (IE 305). It later became a required course in the undergraduate curriculum. IE 425 Production Systems morphed into IE 443 Automation and Production Systems. It was eventually cross-listed with MSE 427 in the Manufacturing Systems Engineering program. Much of the topic material in IE 426 Inventory Theory was incorporated in IE 251 Production and Inventory Control, a required course in the senior year. Finally, IE 427 Queueing Theory disappeared for several years and was reborn as IE 439 Queueing Systems in the 2002-2003 catalog.

George Kane's Legacy. The essence of the Industrial Engineering Department changed significantly during George Kane's 14 years as department chair. Only five of the 10 faculty (at assistant professor level or above) in 1974 remained in 1988. The other five had moved on or passed away. And there were eight new faculty in 1988 that were hired during Kane's term, for a

total of 13. In addition, the department had changed its physical location in 1988. The IE lab facilities and classrooms in Mohler Lab were much superior to those left behind in Packard Lab. The faculty offices were now located along two main hallways on the third and fourth floors of Mohler instead of being scattered all over the building in Packard. And the curriculum had been expanded and improved, with more course offerings, more descriptive course titles, more logical course sequences, and upgrades of individual courses to keep pace with technological advances.

George Kane was an excellent teacher both before and after he became department chair, and that is an important part of his legacy. He received several University awards in recognition of his pedagogical skills. He also had a great sense of humor and was often able to spontaneously turn a seemingly ordinary situation into a humorous event. On one occasion, a student in class asked him a question that he had just answered in reply to a previous question, and he quickly responded “Oh, I’m sorry, did I wake you up?” He had a way of conveying technical subjects with a clarity that made them comprehensible to students, but he also stimulated their interest in the subject. He was at the same time entertaining, informative, and motivating.

Kane enjoyed teaching and maintained almost a full teaching load during his time as chairman. Thus, by example he communicated to his faculty that teaching was important. His area of expertise was manufacturing engineering. The other two areas in which the faculty specialized were operations research and information systems. George was very even-handed in balancing these three areas in terms of hiring faculty and allocating resources. The faculty appreciated the synergistic effect that the three areas contributed to the department.

Kane was highly regarded by his colleagues in the IE department. He was a great mentor and there was a general sense of camaraderie among the industrial engineering faculty. Nowhere was this more evident than at the IE lunch table in the Asa Packer dining room in the University Center. Tucked into the southeast corner of the large room, this is where most of the senior IE faculty ate lunch. The usual group included Adams, Groover, Kane, Monro, Richardson, and Wechsler, with occasional visitors from other departments.

The conversations were often entertaining. One day, the usual group was at the table, including Kane, and they were talking about the supervisory limitations that department chairs face relative to their faculty. Richardson made one of his typical witty observations, “George doesn’t have any control over me or my job. All he controls are my salary and my working conditions.” (What else is there?)

Richardson and Ben Wechsler were two of the regulars at the table. They were about the same age and had both served in World War II, Richardson in the Navy, and Wechsler in the Army. So there was this friendly army-navy rivalry between them, which often took the form of bantering with each other during lunch, always in good humor. On one occasion, the conversation somehow rolled around to the subject of faculty salaries, and Wally commented, “They don’t pay me what I’m worth.” Wechsler lost no time in responding, “And you should be grateful for that.”

George Kane was highly respected within the University at large. As an example of Kane’s standing, he was selected in 1981 to chair the search committee for a new president. Deming Lewis had been Lehigh’s president since 1964 and was nearing retirement. The tradition at Lehigh was to appoint a search committee to identify the most qualified candidate for most



Wallace Richardson, George Kane, and Ben Wechsler (seated) at a computer terminal (circa 1979)

vacant positions, whether faculty or administration. No search committee is ever more important than the one appointed to find a new president. Kane's search committee did its job well, and Peter Likins, formerly the Provost at Columbia University, was named as Lehigh's new president in 1982. Likins served as president for the next 15 years. It was a period of exceptional growth and accomplishment at the university.

Observation. Wallace Richardson and George Kane both died in 1989, Wally in March and George in September. They had been good friends and professional colleagues for 37 years. Kane had started in the department in 1950 and Richardson in 1952. They were both interred in the Holy Savior Cemetery in Bethlehem. Their graves are located next to each other, six feet apart.

Chapter 6 The Marlin Thomas and Louis Martin-Vega Years: 1988–1998

During the period 1988 – 1998, two department chairs were hired from outside of Lehigh. The two previous chairs, Arthur Gould and George Kane, had both held faculty positions at Lehigh before their appointments. Marlin U. Thomas was chairman from 1988 to 1993, and Louis Martin-Vega was chairman from 1994 to 1998. Mikell Groover served as interim chairman during the 1993-1994 academic year.

Marlin Thomas earned his B.S.E. in industrial engineering at University of Michigan at Dearborn in 1967 and his M.S.E. and Ph.D. at University of Michigan at Ann Arbor in 1968 and 1971, respectively. Before coming to Lehigh, he had held faculty positions at the Naval Postgraduate School in Monterey, California, (1971 – 1976), University of Wisconsin at Milwaukee (1976 – 1978), University of Missouri at Columbia (1979 – 1982), and Cleveland State University (1982 – 1987) where he also served as department chairman. In 1987, he was appointed Director, Operations Research Program, Division of Electrical, Communications and Systems Engineering at National Science Foundation in Washington, D.C. He was hired as Professor and Chairman of the Industrial Engineering Department at Lehigh in 1988. Thomas was also in the U.S. Naval Reserves. He was called back into service during the first Gulf War in 1991. He retired at the rank of Captain.



Marlin U. Thomas (circa 1990)

During Thomas's five years as chairman, two new faculty members were hired into the department: Laura Burke and Keith Gardiner. He also oversaw the promotions of five faculty during his term as chairman: Sathyanarayanan to Associate Professor in 1989, Odrey to Professor in 1991, Wu to Associate Professor in 1992, and Storer and Tonkay to Associate Professor in 1993.

Laura I. Burke had earned her B.S. and M.S. in industrial engineering at Pennsylvania State University in 1985. She earned a second M.S. in 1986 and a Ph.D. in 1989 from the University of California, Berkeley. She was hired as an Assistant Professor in 1989 and promoted to Associate Professor in 1994. She was the first female faculty member in IE at Lehigh. Her teaching and research interests are in operations research and neural networks.

Laura took a sabbatical leave in 2000 at Northeastern University and resigned from Lehigh at the end of her sabbatical.

Keith Gardiner had been hired into the Manufacturing Systems Engineering Program in 1987 after a long career with IBM Corporation. His B.S. degree in materials from the University of Manchester (England) was earned in 1953, and he received his Ph.D. in 1957. He is listed in the 1989-1990 Lehigh University catalog as acting director of the center for design and manufacturing innovation and visiting professor of manufacturing systems engineering. In 1989, he was hired into the IE Department at the rank of Professor. In 1992, the name of the Center for Design and Manufacturing Innovation was changed to the Center for Manufacturing Systems Engineering. Gardiner remained Director of the Center as well as the MSE Graduate Program.

During Marlin's first year as chairman, he scheduled a faculty retreat, a day away from campus at which issues facing the department would be discussed. One of the agenda items was the name of the department. Since its inception in 1949, it had always been known as the Department of Industrial Engineering. Should the name be changed to reflect the changes in the practice of industrial engineering that had occurred since 1949? The members of the faculty were divided into groups, each assigned to develop recommendations about the name. After about an hour, representatives from each group presented their findings. Groover represented his group and suggested several alternatives, including the following: "The Department of Enterprise Industrial Engineering, Information, and Optimization." The response was a general scratching of heads by those in attendance. Groover explained: "If that were our name, we would be known as Department E-I-E-I-O." At the conclusion of the discussion, no change was made in the name of the Industrial Engineering Department.



Industrial Engineering Department in 1992. Seated from left: M. Groover, L. Burke, M. Thomas, J. Adams; standing from left: N. Odrey, K. Gardiner, L. Plebani, G. Tonkay, G. Wilson, D. Wu, J. Wiginton, E. Zimmers, R. Storer.

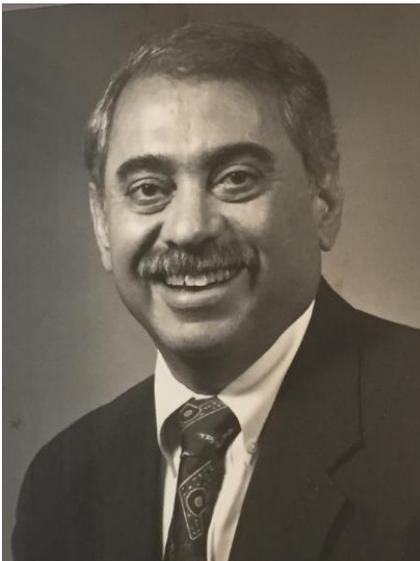
In 1993, Marlin Thomas resigned as Chairman of IE at Lehigh to accept the appointment of Professor and Head of Industrial Engineering at Purdue University. He served in that position from 1993 to 2006, during which time he served a term as President of the Institute of Industrial

Engineers. In 2006, he became Dean, Graduate School of Engineering and Management, Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio.

During the academic year 1993-1994, the name of the IE department was changed to the Department of Industrial and Manufacturing Systems Engineering (IMSE). This change recognized the close association between the department and the Manufacturing Systems Engineering Graduate Program.

Louis Martin-Vega served as Chairman of the Department of Industrial and Manufacturing Systems Engineering from 1994 to 1998. He had received a B.S. in industrial engineering from the University of Puerto Rico at Mayaguez in 1968, M.S. from New York University in 1971, M.E. and Ph.D. from the University of Florida in 1973 and 1975, respectively. Prior to Lehigh, he held faculty positions at University of Florida and University of Puerto Rico at Mayaguez. He had also been Program Director of the Division of Design, Manufacture, and Industrial Innovation at the National Science Foundation.

In 1998, Martin-Vega accepted the position of acting head of the Engineering Directorate at the National Science Foundation. Following NSF, he became the Lockheed Professor in the College of Engineering at Florida Institute of Technology, and then Dean of Engineering at University of South Florida. In 2006, he was appointed Dean of Engineering at North Carolina State University in Raleigh. He served as President of the Institute of Industrial Engineers in 2007-2008 and has received numerous awards from IIE for his service to the Institute and to industrial engineering education.

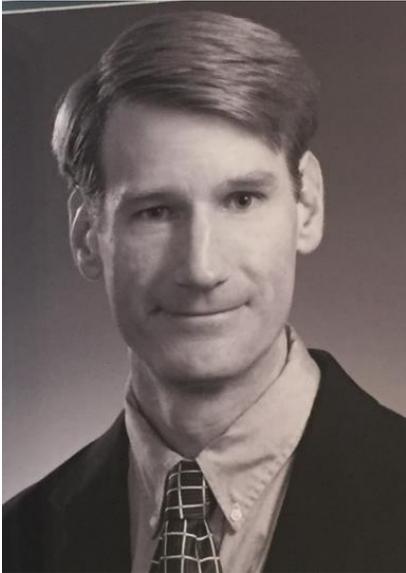


Louis Martin-Vega (circa 1996)

During Martin-Vega's term as chairman, G. Sathyanarayanan was promoted to full professor in 1995, John Adams retired to emeritus status in the same year, and Joe Hartman was hired, first as a visiting assistant professor in 1996 and then as assistant professor in 1997.

Joseph C. Hartman had earned his B.S. in general engineering from University of Illinois at Urbana in 1992 and his M.S. and Ph.D. in industrial and systems engineering from Georgia Institute of Technology in 1994 and 1996, respectively. His research and teaching areas are engineering economy, decision analysis, and applied optimization. He was promoted to Associate Professor in 2002. Hartman is the author of the textbook *Engineering Economy and the Decision Making Process* (Prentice-Hall, 2006). During the 2003-2004 academic year he was

visiting associate professor at the University of Edinburgh in Scotland. He would later become ISE Department Chair, serving from 2004 to 2007.



Joseph C. Hartman (circa 2006)

During Martin-Vega's term as department chairman, the Manufacturing Logistics Institute was co-founded by Professors Robert Storer and David Wu around 1995. As it evolved, the emphasis was broadened beyond supply chain management ("logistics" and "supply chain management" are roughly synonymous) to value chains, and collaboration and sponsorship with the business school was initiated. The Institute changed its name to the Center for Value Chain Management (CVCR). Today, CVCR is largely an operation of the College of Business and Economics.

Industrial Engineering Support Staff. With Faith's departure and Kathy's promotion in 1994, the IMSE office was absent one office administrative position. **Rita Frey** was hired to fill that position. She had been a member of the support staff in the History Department and then Facilities Planning for several years before moving to ISE. Rita started on Valentine's Day, 1994. Her responsibilities gradually evolved into IE graduate program administration. She became the welcoming committee for new graduate students starting in the department. Rita retired from Lehigh in 2017, having served the department with distinction for more than 23 years.

Ed Force II was hired as technician in the Manufacturing Technology Laboratory when Gil Zambelli retired. Ed had served in the United States Air Force specializing in electronics. He had originally been hired into Lehigh as robotics technician for the Manufacturing Systems Engineering Program in 1984. When the opening became available in the Manufacturing Technology Lab in 1991, he made a lateral transfer. He quickly overcame his lack of background in machine tool technology. In fact, his strengths in electronics and computers proved to be the more important skills as the lab moved into new technologies that required these skill sets. He turned out to be a great hire, and the person responsible should be commended for the foresight demonstrated by that hiring decision. Ed's responsibilities increased over the years to include oversight not only of the Manufacturing Technology Lab, but also the ISE Department's personal computers and classroom audio/visual equipment. Two other technicians were hired to

assist Ed and help with the other labs in the department: **Joe Griffiths** from 1999 to 2002, and **Hyung Kim** from 2002 to 2005. In 2005, Ed was promoted to engineering technician.

Industrial Engineering B.S. Curriculum: 1998. The undergraduate curriculum in industrial engineering listed in the 1998-1999 university catalog included 49 required IE courses, increased from 43 in 1988. The IE major was as follows (only the IE courses are listed):

Sophomore year:

- IE 111. Engineering Probability and Statistics (3 cr hr)
- IE 112. Computer Graphics (1 cr hr)
- IE 121. Applied Engineering Statistics (3 cr hr)
- IE 122. Software Tools (1 cr hr)
- IE 131. Work Systems and Facilities Planning (3 cr hr)
- IE 132. Work Systems Laboratory (1 cr hr)

Junior year:

- IE 115. Fundamentals of Modern Manufacturing (3 cr hr)
- IE 116. Manufacturing Laboratory (1 cr hr)
- IE 124. Engineering Economy (3 cr hr)
- IE 221. Operations Research – Probabilistic Models (3 cr hr)
- IE 222. Operations Research – Deterministic Models (3 cr hr)
- IE 224. Information Systems Analysis and Design (3 cr hr)
- IE 305. Simulation (3 cr hr)

Senior year:

- IE 154. Senior Project (3 cr hr)
- IE 251. Production and Inventory Control (3 cr hr)
- IE 300-level Electives (12 cr hr)

New 300-level electives had been added since the 1988-1989 catalog:

- IE 316. Advanced Operations Research Techniques (3 cr hr)
- IE 319. Material Handling and Facilities Planning (3 cr hr)
- IE 339. Queueing Theory (3 cr hr)

And two 300-level courses that were in the 1988-1989 catalog had been dropped by 1998:

- IE 317. Probabilistic Models II (3 cr hr)
- IE 318. Deterministic Models II (3 cr hr)

The fact is that the undergraduate curriculum had changed very little in 10 years. Aside from the 300-level elective changes, the only notable difference was that IE 305 Simulation was now a required course in the junior year. The faculty were comfortable with the required courses and 300-level electives in the program.

IMSE Graduate Program. At the graduate level, two new M.S. programs had been added to the industrial engineering line-up in the 1998-1999 catalog: M.S. in Manufacturing Systems Engineering (MSE) and M.S. in Quality Engineering (QE). The M.S. in MSE was now included among the masters programs in the Industrial and Manufacturing Systems Engineering Department in addition to its separate catalog listing as a graduate program in Manufacturing Systems Engineering. The QE program had been launched during the 1993-1994 academic year and was “designed to accommodate part-time students who are employed full-time. All courses are offered by satellite so that students whose employers provide down link equipment can

complete the requirements for the degree without coming to campus.” The IMSE Department was now in the satellite education business.

New 400-level electives had been added since the 1988-1989 catalog, two of which were designed specifically for the quality engineering masters program:

IE 421. Nontraditional Manufacturing Processes (3 cr hr)

IE 422. Measurement and Inspection Systems (3 cr hr)

IE 426. Artificial Neural Networks (3 cr hr)

IE 442. Total Quality Management (3 cr hr)

IE 448. Industrial Control Systems for Manufacturing (3 cr hr)

IE 458. Game Theory (3 cr hr)

Two 400-level courses that were in the 1988-1989 catalog had been dropped by 1998:

IE 428. Advanced Work Systems (3 cr hr)

IE 444. Design of Cutting Tools (3 cr hr)

Observation. Lehigh University has the distinction that three of its former industrial engineering faculty members have served as president of the Institute of Industrial Engineers: William A. Smith (1974-1975), Marlin U. Thomas (2001-2002), and Louis Martin-Vega (2007-2008). Unfortunately, the honor is somewhat diminished by the fact that none of them served while they were at Lehigh.

Chapter 7 The David Wu and Joe Hartman Years: 1998–2008

Marlin Thomas and Louis Martin-Vega were both external candidates when they were hired as department chairmen. Hiring them had required time-consuming search processes that each took the better part of a year. When Martin-Vega took a leave of absence after only four years as chair (1994 – 1998) to accept a high-level position at the National Science Foundation, the Dean of the College of Engineering and Applied Science, Harvey Stenger, decided to appoint an internal candidate in the person of S-Y. David Wu, who served the department as chairman from 1998 to 2004.



Szu-Yung David Wu (circa 2004)

During David's term as department chair, the name of the department was changed in 2001 from Industrial and Manufacturing Systems Engineering (IMSE) to Industrial and Systems Engineering (ISE), seven new faculty were hired, and several new programs were introduced.

New Faculty 1998 – 2004. During David's tenure, seven new faculty were added to the department: Theodore K. Ralphs, Eugene Perevalov, Andrew M. Ross, Rosemary T. Berger, Jeffrey T. Linderoth, Lawrence V. Snyder, and Aurelie Thiele.

Theodore K. Ralphs was hired in 2000 as an assistant professor in the department. He had received his B.S. and M.S. in mathematics, both in 1991, from Carnegie Mellon University, and his Ph.D. in 1995 in industrial engineering and operations research from Cornell University. From 1995 to 2000, he served in the U.S. Air Force. Ted's teaching and research interests are related to mathematical optimization, mathematical programming, high performance computing, and the development of algorithms in systems engineering.

Eugene Perevalov had earned an M.S. in physics from the Moscow Engineering Physics Institute (Russia) in 1993 and a Ph.D. in physics in 1998 from the University of Texas at Austin, after which he spent several years as a Post-doctorate in operations research at the Massachusetts Institute of Technology and Harvard University. He was hired into Lehigh as an assistant professor in 2001. His teaching and research areas include statistics, operations research, dynamic optimization, information theory, game theory, and financial engineering.

Andrew M. Ross was hired as an assistant professor in 2002 after completing his Ph.D. in 2001 from the University of California at Berkeley in operations research. He had earned a B.S.

in 1996 in mathematics from Harvey Mudd College and an M.S. in 1997 from U.C.-Berkeley. His teaching areas are related to probability and statistics. Ross left Lehigh in 2006 and accepted a faculty position at Michigan State University.

Rosemary T. Berger had received her B.S. in mathematics in 1992 from College of William and Mary, and her M.S. and Ph.D. in industrial engineering and management sciences from Northwestern University in 1993 and 1997, respectively. She had spent several years in industry at Level3 Communications before being hired in 2002 as an assistant professor at Lehigh. Her teaching and research interests are in operations research. She resigned from Lehigh in 2006 and joined the Morgridge Institute for Research in Madison, Wisconsin, as an optimization support specialist.

Jeffrey T. Linderoth was also hired in 2002 as an assistant professor, after earning a B.S. in 1992 from the University of Illinois at Urbana-Champaign, an M.S. and Ph.D. in industrial engineering and operations research at Georgia Institute of Technology in 1994 and 1998, respectively. During the period between earning his doctorate and starting at Lehigh (1998 – 2002), he worked for a small start-up company focusing on finance optimization. His field of interest is mathematical optimization. Linderoth left Lehigh in 2007 to join the faculty at University of Wisconsin in Madison. He became chair of the department in 2017.

Lawrence V. Snyder received a B.A. in 1996 in mathematics at Amherst College and was hired into Lehigh in 2003 as an assistant professor after earning his M.S. and Ph.D. in industrial engineering and management sciences from Northwestern University in 1999 and 2003, respectively. He was promoted to associate professor in 2010. His teaching and research interests include applied optimization, facility location, production and inventory control, logistics and supply chain management. He is co-author of a textbook titled *Fundamentals of Supply Chain Theory* (Wiley, 2011).

Aurelie Thiele was hired as an assistant professor in the department in 2004, after completing her M.S. and Ph.D. in electrical engineering and computer science at the Massachusetts Institute of Technology in 2000 and 2004, respectively. Her undergraduate studies were in control systems theory at Ecole des Mines de Paris in Paris France before immigrating into the United States. Her teaching and research interests include robust optimization and financial engineering. She was promoted to associate professor in 2010. Aurelie would resign her position at Lehigh, effective July 2017, to accept an appointment at Southern Methodist University in the Department of Engineering Management, Information, and Systems.

Of the seven faculty members hired during Wu's term as chairman (1998–2004), three remain at Lehigh: Ted Ralphs, Eugene Perevalov, and Lawrence Snyder.

ISE Leadership Changes. In 2004, David Wu was selected to become Lehigh's Dean of Engineering and Applied Science, a position he occupied until 2015. This was indeed an honor for the Industrial and Systems Engineering Department. Never before had an IE faculty member been chosen as dean of engineering at Lehigh. In 2015, Wu retired from Lehigh and was appointed Provost and Executive Vice President at James Mason University, one of the schools in the Virginia State University system.

When David Wu became Dean of Engineering and Applied Science in 2004, he appointed Joe Hartman as Department Chair of Industrial and Systems Engineering while Joe was still an associate professor. Hartman served as chairman from 2004 to 2007. During that period he also

held the George N. Kledaras Chaired Professorship. Joe resigned from Lehigh in 2007 to become Chairman of the Industrial and Systems Engineering Department at University of Florida in Gainesville. In 2013, he was appointed Dean of the Francis College of Engineering at the University of Massachusetts in Lowell.



Theodore K. Ralphs and
Joseph C. Hartman (2011)

During the 2007–2008 academic year, Greg Tonkay served as interim chair of ISE, while an external search was made to identify a permanent chair of the department. The search was successful and in the Fall semester 2008, Tamas Terlaky became the Chairman of the Industrial and Systems Engineering Department at Lehigh. He was also awarded the George N. and Soteria Kledaras Endowed Chair Professorship.

Industrial Engineering Support Staff. As the programs and laboratories related to industrial engineering grew during the 1990s, new positions were added in the IE Department. As IE Chairman, David Wu hired **Ann Warnecke** in 2000 to be the IGERT coordinator for a major NSF research program he had been awarded. Her position lasted from 2000 through 2003, when **Valerie Holt** was hired to replace Ann. When David became dean of engineering in 2004, he brought Valerie along to be his executive assistant. The vacated position in IE evolved into a communications coordinator and then communications specialist, filled by **Jane L. Kline** (2005-2008), **Amanda Fabrizio** (2008-2013), and **Abby Barlok** (hired in 2013). Responsibilities of this position included editing the annual department newsletter, administration of the annual ISE Banquet and other department functions, and general communications with IE alumni.

Meanwhile, the Computer-Integrated Manufacturing Laboratory had expanded from its beginnings in 1976 to become an administrative unit of the department called the Enterprise Systems Center (ESC), engaging in project work and research for local industry and other organizations under the general direction of Emory Zimmers. Among the support staff positions in the 1980s were **Andrea Witchen** and **Chandu Marathe**, who participated in writing and managing projects in the ESC. **Joan Fox** was hired as administrative coordinator in 1987 and became financial coordinator in 2007. Joan retired from Lehigh in 2011. **Myethrei Shaker** was then hired as a Lehigh employee after working for many years in the center. **Michael McDougall** originally started working for the ESC in 1995 and was hired in 2007 as technical coordinator.

Integrated Business and Engineering (IBE) Honors Program. While chairman of ISE, David Wu participated in the development of three new programs at Lehigh: (1) an interdisciplinary

undergraduate program titled the Integrated Business and Engineering (IBE) Honors Program, (2) an undergraduate program in Information and Systems Engineering, and (3) a graduate program leading to the M.S. degree in the same field.

Early during David's term as IMSE Department Chair, he was asked to co-chair a university task force to develop the curriculum and details of a new program that would be offered jointly by the College of Business and Economics and the P.C. Rossin College of Engineering and Applied Science. The idea for the program came from Lehigh's new president, Gregory Farrington, who started at Lehigh in 1998, the same year David became Chairman of ISE. Prior to his appointment at Lehigh, Farrington had been Dean of Engineering at University of Pennsylvania and had witnessed the success of a program at Penn called the Jerome Fisher Management and Technology Program. Owing to Lehigh's strengths in engineering and business, he reasoned that a similar offering at Lehigh would have merit. The task force completed its work, the program was approved by the university faculty in December 1999, and the Integrated Business and Engineering Honors Program was first announced in the 2000-2001 catalog. At the time of its introduction, it was one of only a few such undergraduate programs in the United States.

The mission of the program is "to produce graduates with a unique set of skills and competencies: In addition to the mastery of the concepts and procedure taught in individual courses in each college, the IBE Honors Program develops competencies that require an integrated knowledge from both engineering and business. This program recognizes the need for today's leaders in business and industry to have a sound foundation in both commerce and technology."

Students are required to select a major in either business or engineering. A total of 137 credit hours are required to complete the program, including 12 credit hours that are specifically designated as IBE courses throughout the four year program.²¹ IBE students are also required to maintain at least a 3.25 grade point average, consistent with the definition of "Honors Program."

Directors of the IBE program are Robert H. Storer, Professor of Industrial and Systems Engineering, for the College of Engineering and Applied Science; and Stephen G. Buell,²² Professor of Finance and Business Information Systems, for the College of Business and Economics.

The IBE Honors Program has been very successful for Lehigh University, with an average of around 35 IBE graduates per year, as of 2014. It also seems that the IBE Program has had a beneficial collateral effect on freshman applications and enrollments, just by the positive awareness about Lehigh created by its existence. The program has also been very successful for the ISE Department, which has seen the highest proportion of student enrollments of any other business or engineering major participating in IBE.

Programs in Information and Systems Engineering. In addition to the IBE program, which is a college-level program jointly offered by business and engineering, two new programs were developed in the ISE Department under David's leadership. The B.S. and M.S. programs in Information and Systems Engineering (I&SE) were first introduced in the 2002-2003 catalog.

²¹ For comparison, a total of 130 credit hours are required to complete the industrial and systems engineering curriculum.

²² Stephen Buell graduated in 1970 with a B.S. degree in Industrial Engineering from Lehigh University.

The objective of the B.S. program is to produce “graduates who understand the complex facets of modern information systems, and the integration of these systems in industrial, service, and financial organizations.” The undergraduate curriculum is focused on three core areas: (1) information economics, (2) quantitative systems analysis, and (3) information technology. The curriculum details of the Information and Systems Engineering undergraduate program in the 2010-2011 academic year are presented in Chapter 8.

The 30-credit-hour M.S. Program in I&SE provides “advanced educational opportunities related to operations research, quantitative and computational analysis, large scaled optimization, system simulation, and the integration of information systems in industrial, service, and financial organizations.



Industrial and Systems Engineering Department in 2002. Seated from left: E. Perevalov, G. Tonkay, K. Gardiner, J. Hartman; standing from left: N. Odrey, L. Plebani, G. Wilson, T. Ralphs, E. Zimmers, R. Storer, D. Wu, J. Adams, M. Groover.

Chapter 8 The Tamas Terlaky Years: 2008–2017²³

Tamas Terlaky had earned the M.Sc. in mathematics in 1979 and Dr. of Natural Sciences (Ph.D.) in 1981 from Lorand Eotvos University (Hungary). Prior to his appointment at Lehigh, he had held faculty and administrative positions at McMaster University (Canada), Strathclyde University (Scotland), University of Veszprem (Hungary), Delft University of Technology (The Netherlands), and Eotvos University (Hungary). Terlaky's teaching and research interests include operations research, mathematical programming, and mathematical optimization. He has received numerous honors and awards and has chaired major conferences and symposia in these fields. Among Terlaky's publication credits are four co-authored books on various topics in optimization, editor or co-editor of seven edited volumes, and guest editor of seven special issues of scientific journals.



Tamas Terlaky (2011)

During Terlaky's first two years as department chair (2008–2010), two visiting professors were hired for two-year appointments, and two tenure-track appointments were made: Frank E. Curtis as assistant professor and Katya Scheinberg as associate professor. The two visiting professors departed in 2010 to take positions at other organizations, one in industry, the other in academia.

Frank E. Curtis had received his B.S. in mathematics and computer science (double major) from College of William and Mary in 2003, and his M.S. and Ph.D. in industrial engineering and management sciences from Northwestern University in 2004 and 2007, respectively. He had spent 2007 – 2009 as a postdoctoral researcher at the Courant Institute of Mathematical Sciences at New York University before being hired as an assistant professor at Lehigh in 2009. He was promoted to associate professor in 2015. His teaching and research interests include mathematical optimization and operations research.

Katya Scheinberg received her M.S. degree from the Lomonosov Moscow State University (in Russia), and a BA degree in 1992 from Columbia University. She continued her studies at

²³ Although Tamas Terlaky's term as Chairman of ISE ran from 2008 to 2017, this historical account only runs to the end of 2010, which is when the author retired from Lehigh. It is the author's ambition that the chronicle of his many initiatives and accomplishments for the department may someday be completed.

Columbia, earning an M.S. in 1994 and Ph.D. in 1997. She started her career at the Thomas Watson Research Laboratories of IBM Corporation. In 2010, she was hired into Lehigh at the level of associate professor. Her teaching and research interests are in mathematical optimization, operations research, and machine learning. During her years at IBM, she co-authored a book titled *Introduction to Derivative Free Optimization* (Society for Industrial & Applied Mathematics, 2008). She was promoted to full professor in 2014 and awarded the Harvey E. Wagner Endowed Chair in Manufacturing Systems Engineering. In 2014-2015, she was Lehigh's ADVANCE chair, an NSF program for the advancement of women in science, technology, engineering, and mathematics (STEM).

Industrial Engineering B.S. Curriculum: 2010. The undergraduate curriculum in industrial engineering listed in the 2010-2011 university catalog was as follows (only the IE courses are listed):

Sophomore year:

- IE 111. Engineering Probability and Statistics (3 cr hr)
- IE 112. Computer Graphics (1 cr hr)
- IE 121. Applied Engineering Statistics (3 cr hr)
- IE 131. Work Systems and Operations Management (3 cr hr)
- IE 132. Work Systems Laboratory (1 cr hr)

Junior year:

- IE 122. Software Tools (1 cr hr)
- IE 215. Fundamentals of Modern Manufacturing (3 cr hr)
- IE 216. Manufacturing Laboratory (1 cr hr)
- IE 220. Introduction to Operations Research (3 cr hr)
- IE 224. Information Systems Analysis and Design (3 cr hr)
- IE 226. Engineering Economy and Decision Analysis (3 cr hr)
- IE 305. Simulation (3 cr hr)

Senior year:

- IE 154. Senior Project (3 cr hr)
- IE 251. Production and Inventory Control (3 cr hr)
- IEOR elective: IE 316. Optimization Models and Applications **or** IE 339. Stochastic Models and Applications (3 cr hr)
- IE 300-level Electives (12 cr hr)

A comparison of this curriculum with the one 12 years earlier reveals that the following changes had been made:

- The title of IE 111 had been changed from Engineering Probability and Statistics to Engineering Probability.
- The title of IE 131 had been changed from Work Systems and Facilities Planning to Work Systems and Operations Management.
- IE 122. Software Tools had been moved from the sophomore year to the junior year.
- IE 226. Engineering Economy and Decision Analysis replaced IE 124. Engineering Economy in the junior year.
- The two introductory courses in operations research in the junior year (IE 221. OR-Probabilistic Models and IE 222. OR-Deterministic Models) had been combined into IE 220. Introduction to Operations Research plus an option in the senior year to select either IE

316 or IE 339 or to take both of these courses, counting one of them as an IE 300-level elective.

Information and Systems Engineering B.S. Curriculum. This program (I&SE) had been launched in 2002 during David Wu’s tenure as chairman. It had been designed to produce “graduates who understand the complex facets of modern information systems, and the integration of these systems in industrial, service and financial organization.” The program published in the 2010-2011 catalog was as follows (only IE courses and one required course in Computer Science and Engineering are listed):

Sophomore year:

IE 111. Engineering Probability and Statistics (3 cr hr)
IE 121. Applied Engineering Statistics (3 cr hr)
IE 172. Algorithms in Systems Engineering (3 cr hr)
CSE 18. Data Structures and Programming (3 cr hr)

Junior year:

IE 122. Software Tools (1 cr hr)
IE 220. Introduction to Operations Research (3 cr hr)
IE 224. Information Systems Analysis and Design (3 cr hr)
IE 226. Engineering Economy and Decision Analysis (3 cr hr)
IE 275. Fundamentals of Web Applications (3 cr hr)
IE 305. Simulation (3 cr hr)

Senior year:

IE 154. Senior Project (3 cr hr)
IE 316. Optimization Models and Applications (3 cr hr)
IE 339. Stochastic Models and Applications (3 cr hr)
IE 372. Systems Engineering Design (3 cr hr)
Technical Electives from approved list of courses (12 cr hr)

New courses introduced to implement the Information and Systems Engineering program were the following (titles listed above): IE 172, IE 275, and IE 372. Several new 300-level electives also had been added by 2010 to serve both the IE and I&SE curricula:

IE 358. Game Theory (3 cr hr)
IE 362. Logistics and Supply Chain Management(3 cr hr)
IE 382. Leadership Development (3 cr hr)
IE 385. (Leadership) Honors Project Seminar (1 cr hr)

The names of two 300-level courses had been changed by 2010:

IE 324. Industrial Automation and Robotics (3 cr hr) changed from Industrial Robotics
IE 339. Stochastic Models and Applications (3 cr hr) changed from Queueing Theory

And two 300-level courses that were in the 1998-1999 catalog had been dropped by 2010:

IE 342. Computer Integrated Manufacturing (3 cr hr)
IE 343. Microprocessor Systems in IE (3 cr hr)

The introduction of a new undergraduate program in Information and Systems Engineering was a major new undertaking by the department. On the other hand, the required undergraduate curriculum in Industrial Engineering had hardly changed since 1998, except for a few adjustments in 300-level courses.

ISE Graduate Programs. At the graduate level, lack of interest in the M.S. in Quality Engineering program had reduced it from a 30-credit hour program to a four-course certificate program available by satellite only. Similarly, the graduate program in Information and Systems Engineering had been incorporated into the M.S. in Industrial Engineering as a specialty field of study titled “Information Systems.” The M.S. in Manufacturing Systems Engineering program was still available but only offered by satellite to distance students. The M.S. and Ph.D. programs in Industrial Engineering were highly populated and the department frequently claimed the highest graduate enrollments in the P.C. Rossin College of Engineering and Applied Science.

New 400-level electives had been added since the 1998-1999 catalog, many of which representing the growing interest in operations research and mathematical optimization among ISE faculty:

- IE 406. Mathematical Programming (3 cr hr)
- IE 412. Quantitative Models of Supply Chain Management (3 cr hr)
- IE 413. Advanced Engineering Economy and Replacement Analysis (3 cr hr)
- IE 414. Heuristic Methods in Combinatorial Optimization (3 cr hr)
- IE 418. Integer Programming (3 cr hr)
- IE 425. Inventory Management and Production Planning (3 cr hr)
- IE 441. Financial Engineering Projects (3 cr hr)
- IE 445. Assembly Processes and Systems (3 cr hr)
- IE 446. Discrete Event Dynamic Systems (3 cr hr)
- IE 447. Financial Optimization (3 cr hr)
- IE 451. Intelligent Manufacturing Systems (3 cr hr)

The following 400-level course was dropped in the 2010 catalog compared to the 1998-99 catalog: IE 421. Nontraditional Manufacturing Processes (3 cr hr)

And either the course titles or numbers were changed for the following courses in the 2010 catalog compared to the 1998-99 catalog:

- IE 409. Time Series Analysis (3 cr hr) title changed from Data Dependent Systems
- IE 417. Nonlinear Programming (3 cr hr) title changed from Advanced Mathematical Programming
- IE 426. Optimization Models and Applications (3 cr hr) title changed from Artificial Neural Networks
- IE 429. Stochastic Models and Applications (3 cr hr) title changed from Artificial Intelligence Techniques in Combinatorial Optimization
- IE 439. Queuing Systems (3 cr hr) title changed from Applications of Stochastic Processes
- IE 442. Manufacturing Management (3 cr hr) number changed from IE 415
- IE 458. Topics in Game Theory (3 cr hr) title changed from Game Theory

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Appendix: ISE Faculty and Staff Honors and Awards

Lehigh University Awards

Christian & Mary Lindback Award for Distinguished Teaching, awarded to a member of the teaching staff for distinguished teaching performed during the academic year. ISE winners (year of award):

George E. Kane (1970)
Wallace J. Richardson (1986)
Mikell P. Groover (1995)
Gregory L. Tonkay (2005)
Robert H. Storer (2009)
Emory W. Zimmers, Jr. (2011)

Hillman Faculty Award, awarded for excellence in teaching or research work, or for advancing the interests of the University, or for a special financial need requiring aid, or for any other reason deemed just and proper. ISE winners (year of award):

Arthur F. Gould (1974)
George E. Kane (1980)

Alfred Noble Robinson Faculty Award, awarded annually to a faculty member who has shown extraordinary enthusiasm for Lehigh's goals and priorities, often working beyond his/her direct area/unit on University-wide projects or committees; nominees must be below the rank of associate professor. ISE winners (year of award):

George E. Kane (1959)
William A. Smith, Jr., (1961)
Emory W. Zimmers, Jr. (1976)
Laura I. Burke (1992)
Joseph C. Hartman (2001)

Deming Lewis Faculty Award, voted by the members of 10-year reunion class to the faculty member who "most significantly influenced their members' educational experience." ISE winners (year of award):

George E. Kane (1988)
Mikell P. Groover (1991)
Wallace J. Richardson (1994)
Robert H. Storer (2012)

ISE Teacher of the Year Award, Industrial and Systems Engineering Department, awarded to an ISE faculty member for outstanding teaching and distinguished service during the current academic year, as voted by the ISE undergraduate students. ISE winners (year of award):

Emory W. Zimmers, Jr. (1991, 1995, 1996, 2000)
Robert H. Storer (1992, 2002, 2011, 2012, 2013, 2014, 2015, 2016, 2017)
Mikell P. Groover (1993, 1994, 1997, 2001, 2003, 2007, 2009, 2010)
Gregory L. Tonkay (1998)
Andrew Ross (2004, 2005, 2006)
Nicholas G. Odrey (2008)
Joseph C. Hartman (1999)

ISE Teacher of the Year Award, Masters Program, Industrial and Systems Engineering Department, awarded to an ISE faculty member for outstanding teaching and distinguished service during the current academic year teaching Masters level courses, as voted by the ISE graduate students. ISE winners (year of award):

Lawrence V. Snyder (2015)

Eugene Perevalov (2016)

Martin Takac (2017)

ISE Teacher of the Year Award, Ph.D. Program, Industrial and Systems Engineering Department, awarded to an ISE faculty member for outstanding teaching and distinguished service during the current academic year teaching Ph.D. level courses, as voted by the ISE graduate students. ISE winners (year of award):

Frank E. Curtis (2015, 2016)

Lawrence V. Snyder (2017)

Tradition of Excellence Awards, awarded to an individual staff member or staff team that demonstrates outstanding behaviors or produces exceptional results, either within a single department or across the university. ISE winners (year of award):

Edwin Force II, Individual Award (2005, 2011)

Rita R. Frey and Kathy G. Rambo, Team Award (2008, 2013)