COLLEGE OF ENGINEERING

- **Materials Science Program**
- **Chemical Engineering**
- **Civil Engineering**
- **Electrical Engineering**
- **Mechanical Engineering**
- **Department of Air Force ROTC**

Engineering is a profession which combines mathematics and science with creativity and design to serve the technological needs of our society. The profession demands considerable intellectual ability, and the most successful engineers exhibit the leadership and drive needed to bring to fruition unique solutions to difficult technical problems.

The last twenty-five years have been filled with many technological advances. The space program has made space exploration nearly routine, and a satellite communication system connects the world through television. The computer is now a major item of commerce, and many homes have sophisticated personal computing systems. Bioengineering has advanced rapidly and shows promise of making readily available substances of great complexity and value, such as human insulin. Materials science has made important advances in developing high-performance products, particularly in the area of composite materials.

Engineers are problem solvers. Our society, particularly our economy, has become increasingly dependent on technological innovation. The solutions provided by engineers must be economically viable, technically sound, and socially responsible. The training engineers receive is, therefore, intense. It provides the skills required to be productive in research, development, planning, design, construction, manufacturing, management, teaching, and sales. The College of Engineering is a leader in many fields of research such as catalytic science and technology, composite materials, computer networking, environmental engineering, transportation engineering, coastal engineering, and energy conversion. The research activities of the College are incorporated quickly into its courses. Consequently, research and teaching are closely associated activities.

OPPORTUNITIES FOR ENGINEERS

Engineering graduates have opportunities for employment within a wide range of activities in industry, government, and private practice. An engineering education produces individuals who possess good analytical skills, who are unafraid of quantitative arguments, and who are highly organized and technically competent. Such persons are important members of society and are valued in all aspects of engineering and management. After establishing professional credentials, engineers often become the major decision makers in technologically based organizations.

The University's engineering program provides an excellent preparation for graduate study. An increasingly

large fraction of engineering graduates continue their engineering education to the master's or doctoral degree. Some students continue their studies in the allied fields of science or mathematics, and a few elect to pursue other professional programs such as business, law or medicine.

PREPARATION FOR THE STUDY OF ENGINEERING

A sound high school academic program in mathematics, science, computers, and English is essential preparation for engineering. Engineers use mathematics as a language to describe complex problems, and success in mathematics and science courses is a good indicator of proper preparation. Prospective engineering students should take the honors or advanced placement mathematics program in high school and seek to apply mathematics in their science courses. All engineering programs require students to be well grounded in chemistry and physics, and students considering chemical engineering or the environmental area of civil engineering should take advanced high school courses in the biological sciences. Engineers must be skilled in reading, composition, and exposition. Therefore, prospective engineering students should take English courses that stress critical reading and writing. Additionally, although a foreign language is not required for an engineering major, competence in a foreign language can be valuable in the practice of engineering.

ENGINEERING PROGRAMS

The College of Engineering offers instruction leading to the degrees of Bachelor of Chemical Engineering, Bachelor of Civil Engineering, Bachelor of Electrical Engineering, and Bachelor of Mechanical Engineering. These degree programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The College has 74 full-time faculty members instructing approximately 1,000 undergraduates. Air Force ROTC is also a department in the College.

In addition to these four-year degree programs, five-year programs are offered jointly by each of the four engineering departments and the College of Arts and Science. These programs lead to a bachelor's degree from the College of Arts and Science and a bachelor's degree in the selected engineering field. Descriptions of the individual curricula are given in the Arts and Science-Engineering Curricula section of this catalog.

For those who wish to pursue studies beyond the bachelor's degree, each of the four engineering departments as well as the interdepartmental Materials Science Program offers specialized instruction leading to a master's degree and a Ph.D. degree. Advanced undergraduates may take certain graduate-level courses with the approval of their adviser and the course instructor.

A joint 5 1/2-year program offered by the College of Engineering and the College of Business and Economics leads to a baccalaureate degree in one of the four engineering majors and the Master of Business Administration degree. Admission to this joint program is by application to the Dean of Engineering during the third year of engineering study.

The Resources to Insure Successful Engineers (RISE) Program provides financial, academic, and social assistance to minority engineering students. The objective of the program is to increase the number of minority members in the engineering profession. The program begins with a pre-freshman Summer Academy and continues to graduation. Interested individuals should contact the Office of the Dean of Engineering or the University Admissions Office.

ENGINEERING COURSE ORGANIZATION

The curriculum of each engineering department consists of four basic parts: (1) mathematics and science courses, (2) engineering courses, (3) technical elective courses, and (4) general education courses.

The mathematics, chemistry, and physics courses provide the foundation of the engineering program. These courses are a major part of the curriculum in the freshman and sophomore years.

The engineering courses deal with such subjects as chemical kinetics, digital systems, electrical networks, fluid and solid mechanics, materials science, thermodynamics, and transport phenomena. Engineering courses begin in the first semester of the freshman year and are different in each department. Instruction is carried out in both the classroom and the laboratory. In general, sophomore and junior engineering science courses provide the background for the application and design-oriented engineering courses at the senior level.

Technical elective courses allow students to investigate the sciences in more depth and to develop a concentration within their own discipline. Technical electives also make it possible for students to broaden their perspective in interdisciplinary areas such as applied chemistry and catalysis, biomedical engineering, computer-aided design, materials science, composite materials, digital systems, environmental engineering, and coastal engineering. New areas are developing constantly because faculty research is incorporated into course offerings, particularly at the advanced level.

The general education courses are chosen from the liberal arts to provide engineering students with a well-rounded education. The complete General Education

Program consists of 24 or 25 credits of study that include the University's ENGL 110 freshman writing course and multicultural course requirements, a College requirement for 18 credits chosen from the humanities and social sciences, and certain specific courses required by individual engineering departments. The College's humanities and social sciences requirement is described in more detail in the following section. The specific requirements of each department are given in the appropriate departmental section.

COLLEGE GENERAL EDUCATION PROGRAM

The College of Engineering requires students to take six courses (minimum of 18 credits) chosen from the humanities and social sciences subject to the constraints listed below and the approval of the faculty adviser. The courses selected must provide both breadth and depth and not be limited to a selection of unrelated introductory courses. The University's multicultural course requirement may be included in this set of six courses.

a) At least two courses (minimum of six credits) must be in the humanities. Humanities include Art History, English (except ENGL 110 and other writing skills courses), Foreign Languages and Literatures (except introductory skills courses), Foreign Languages (except the student's native language and introductory skills courses), History, Music (except skills and performance courses), Philosophy (except PHIL 100, 105, 205 and 351), and Theatre (except skills and performance courses).

b) At least two courses (minimum of six credits) must be in the social sciences. The social sciences include Economics (EE majors require ECON 151 or another approved course), Linguistics (except introductory skills courses and LING 301), Political Science, Psychology (except PSYC 309 and 314), and Sociology.

c) At least two courses (minimum of six credits) must be above the introductory level, and each must build upon the content of a previous course, as approved by the faculty adviser.

d) At least two of the six courses (minimum of six credits) must be thematically related, typically in the same department or program. (Chemical Engineering majors have an additional department requirement. See Major Requirements External to the College under Chemical Engineering.)

Many courses in Anthropology, Geography, Black American Studies, Women's Studies, American Studies, Center for Science and Culture, and the University Honors Program may be used to satisfy requirements in the General Education Program. Those which qualify must be individually classified as humanities or social sciences courses according to their content. Courses classified as "Group D" (mathematics and science) by the College of Arts and Science may not be used to satisfy any General Education Program requirement. Students should consult their faculty advisers or the Office of the Dean of Engineering for the proper classification of general education courses.

The humanities and social science component of the engineer's education is extremely important. Students should plan a sequence of courses that are connected by some theme. A good program has an introductory course followed by more advanced courses in the same field of study. Courses offered through the Honors Program may be ideal for this purpose. However it is accomplished, an engineering graduate will be rewarded by a carefully planned General Education Program.

COLLEGE REGULATIONS

The College requires each engineering student to consult with his or her academic adviser at least twice a year during the designated University advanced registration periods. Students must also obtain approval from their advisers to take courses during the Winter or Summer Sessions and when adding or dropping courses.

Each of the four engineering departments has established minimum academic standards for certain courses and for progression to the sophomore or junior level. The specific standards for each department are given in the appropriate departmental section.

To graduate, all students must satisfy the University's writing and multicultural course requirements and attain a cumulative index of at least a 2.0 in all University course work. Additionally, engineering students must have at least a 2.0 average in all engineering, mathematics, and science courses used to fulfill graduation requirements. If a course is repeated, only the last grade will be used to compute the engineering grade-point average; however, all grades are used to compute the University's cumulative grade-point index.

CLASS OPENINGS FOR NONMAJORS

Most courses in the College of Engineering are closed to nonmajors because of limited classroom and laboratory space. Nonmajors with special reasons for enrolling in engineering courses must contact the department chairperson (not the course instructor) to obtain permission to enroll in closed courses. Students who successfully complete closed engineering courses in which they have enrolled without the prior permission of the department chairperson will not automatically be admitted into the engineering major. No closed engineering course will be accepted for transfer without the prior approval of the department chairperson.

Some engineering courses are open to nonmajors. Students do not need special permission to take engineering courses that are part of their curriculum. Students minoring in Civil Engineering are admitted to a large number of civil engineering courses. The requirements for this minor are described in the Civil Engineering section of this chapter.

TRANSFER STUDENTS

The College of Engineering admits a small number of transfer students each year during the fall and spring semesters. Because enrollment in engineering courses is normally restricted to departmental majors, prospective transfer students may not register for engineering courses without prior approval from the chairperson of the appropriate engineering department. The need to control class size and total enrollment in each of the departments frequently requires that nonmajors be administratively removed from class lists following the registration period. Students who transfer into other colleges at the University with the intention of transferring into the College of Engineering at a later time should be aware that the same evaluation process will be used to determine their eligibility to transfer into engineering from within the University.

The engineering curriculum at the University of Delaware is rigorous and has relatively little flexibility. Engineering courses begin in the first semester of the freshman year. Once a freshman class has been admitted, only a limited number of spaces become available within that cohort as it moves through to graduation. Transfer students from outside the University who wish to enter the programs of the College of Engineering are considered along with freshman applicants unless it is judged that they have completed sufficient work to be able to finish their engineering program in three years or less. Candidates for admission as sophomores or juniors will be considered in competition with students transferring internally at the University of Delaware. Since the number of openings is limited in each engineering department, selection for transfer into the College is very competitive. Successful transfer applicants will have a good record in mathematics, science, and engineering courses taken during their last year as a full-time student.

University of Delaware students who wish to transfer into a department of the College of Engineering must make a formal request to the appropriate chairperson by May 1 for entrance in the fall semester or by December 1 for entrance in the spring semester. The student should contact the department office well in advance of these deadlines to determine the specific information that must be included in the application.

Students from colleges outside the University of Delaware who wish to transfer into the College of Engineering must make a formal application through the University Admissions Office by March 1 for entrance in the fall semester or by November 15 for entrance in the spring semester.

It is recommended that students who wish to transfer into the College of Engineering contact the Assistant Dean (135 du Pont Hall, (302) 831-8659) to discuss curriculum requirements and transfer policies before beginning the application process.

MATERIALS SCIENCE PROGRAM

The basic concepts associated with the engineering properties of materials are presented by the Materials Science Program faculty. The introductory course MASC 302 is required by chemical, civil, and mechanical engineering majors and is a prerequisite for the interdepartmental advanced offerings that are available as technical electives. Students in mechanical engineering may elect a Solid Mechanics and Materials option that consists of twelve credits in the area of mechanics and materials. In addition, all engineering departments offer senior projects concerned with the properties of materials. These technical elective courses are strongly recommended for students intending later to pursue master's or doctoral degrees in Materials Science and Engineering.

CHEMICAL ENGINEERING

Most individuals outside of the chemical engineering profession have little understanding of the discipline. Engineering in general is a combination of applied science, analysis and creativity that provides practical solutions to some of the most important problems of the society. Chemical engineering, as its name suggests, pays particular attention to applied chemistry, materials science, and increasingly to biology. Engineering occurs when these basic sciences are transformed into quantitative models and reliable systems are built. There are a few characteristics for chemical engineering analysis: creative, quantitative, applied, and specific. A high degree of creativity is needed to express problems in chemical engineering in ways that give new and effective solutions. Engineering, and particularly chemical engineering, is quantitative, for our solutions state "how much," "how many," and "at what cost." Chemical engineering is applied in that the work product almost always is aimed toward problems that are to be solved within five years and typically lead to commercial products. Chemical engineering is specific in that our models apply to a particular configuration of equipment or to a defined product.

A B.S. chemical engineer has several kinds of employment opportunities, including process development, product development, manufacturing, research and development, process design, and sales. Process development is the invention and modification of ways for making chemicals and chemical products. Product development is the invention of chemical systems that meet marketplace needs. Manufacturing is the operation of biological, chemical or petrochemical plants. Research and development is the invention of new products and processes. (It should be noted that many research opportunities expect the candidate to have an advance degree.) Process design is the organization of chemical equipment to make products at acceptable profit margins while paying attention to environmental and safety issues. Finally, chemical engineers who are gifted in the art of persuasion find opportunities in chemical sales.

Some of the highly visible topics of current technology fit naturally into chemical engineering. For example, modification of genes in relatively simple biological systems is called genetic engineering, but actually is an extension of chemical engineering. The development of artificial organs, such as the pancreas, is an application of chemical engineering. Superconductivity has received great attention in the popular press. The development of superconducting materials stems from material science, part of the domain of chemical engineering. The production of complex chips now requires the analysis of chemical engineers to optimize production. Chemical engineering is in the forefront of many areas of current technology.

Delaware's curriculum in chemical engineering differs from those in most other institutions in that the commitment to an early start in the profession is unusually strong. In the freshman year, the course CHEG 112 applies the student's high school background in science and mathematics to the solution of several engineering problems. Physical Chemistry is introduced earlier than many other schools, and this enables much of the chemical engineering science background to be completed by the end of the third undergraduate year. As a result, the fourth year provides opportunities for pursuit of technical topics of special interest to a depth that may be unique nationally. Furthermore, by obtaining the "flavor" of the discipline early in a college career, students can transfer to other courses of study if chemical engineering turns out to be an inappropriate choice. However, these same characteristics of the program make it difficult for students to transfer into this curriculum during their sophomore or junior years unless the science requirements, especially in chemistry, have been met. Students should note that the course CHEG 112 is a prerequisite for CHEG 231, which in turn is a prerequisite for the courses CHEG 325 and 341. These courses are available only in the semesters indicated in the curriculum outlined below.

The following curriculum has been designed to provide rigorous training in the basic scientific, mathematical, and engineering skills while simultaneously affording motivation and opportunity for application of these skills to the challenges of modern society as posed by faculty who maintain extensive contacts with industry and government.

DEGREE: BACHELOR OF CHEMICAL ENGINEERING
MAJOR: CHEMICAL ENGINEERING

CURRICULUM		CREDITS*
UNIVERSITY REQUIREMENTS		
ENGL 110	Critical Reading and Writing	3^{1F}
Three credits in an approved course or courses stressing multicultural, ethnic, and/or gender-related content #		3^{1-4}
COLLEGE REQUIREMENTS		
General Education Program		18^{2-4}

See page 207: College General Education Program.

MAJOR REQUIREMENTS

External to the College

Biology		
BISC 207	Introductory Biology I	4^{2S}
Chemistry		
CHEM 111	General Chemistry	3^{1F}
CHEM 119	Quantitative Chemistry I	2^{1F}
CHEM 112	General Chemistry	3^{1S}
CHEM 120	Quantitative Chemistry II	3^{1S}
CHEM 443	Physical Chemistry	3^{2F}
CHEM 444	Physical Chemistry	3^{2S}
CHEM 331	Organic Chemistry	3^{3F}
CHEM 333	Organic Chemistry Laboratory I	1^{3F}
CHEM 332	Organic Chemistry	3^{3S}
Mathematics		
MATH 241	Analytic Geometry and Calculus A	4^{1F}
MATH 242	Analytic Geometry and Calculus B	4^{1S}
MATH 243	Analytic Geometry and Calculus C	4^{2F}
MATH 302	Ordinary Differential Equations I	3^{2S}
Physics		
PHYS 207	General Physics	4^{1S}
PHYS 208	General Physics	4^{2F}
Computer Science		
CISC 106	General Computer Science for Engineers	3^{1F}
General Education Program		3^{2-4}

An additional three-credit general education course must be taken in the humanities or social sciences. Furthermore, three of the general education courses (minimum of nine credits) must be in the same department or program, and at least one of these three courses must be above the introductory level. Courses classified as "Group D" by the College of Arts and Science may not be used to fulfill this requirement.

Within the College

MASC 302	Materials Science for Engineers	4^{3F}

*Superior figures indicate semester (fall or spring) and/or year or years in which the course should be taken, i.e. ^{1F}fall of freshman year, ^{2S}spring of sophomore year, etc.
#This requirement may be fulfilled through a course taken to complete major, group, breadth, or elective requirements. See page 26.

Within the Department

CHEG 009	Chemical Engineering Freshman Seminar	0 1F
CHEG 112	Introduction to Chemical Engineering	3 1S
CHEG 231	Chemical Engineering Thermodynamics	3 2F
CHEG 325	Chemical Engineering Thermodynamics	3 2S
CHEG 341	Fluid Mechanics	3 3F
CHEG 332	Chemical Engineering Kinetics	3 3F
CHEG 345	Chemical Engineering Laboratory I	3 3S
CHEG 342	Heat and Mass Transfer	3 3S
CHEG 443	Mass Transfer Operations	3 4F
CHEG 445	Chemical Engineering Laboratory II	3 4F
CHEG 401	Chemical Process Dynamics and Control	3 4S
CHEG 432	Chemical Process Analysis	3 4S

Technical Electives†

General Technical Electives 6 3,4

The purpose of the technical electives is to advance the scientific or engineering background of the chemical engineers at the intermediate (300-400) level. The technical electives program is a minimum of six credits taken from courses in the following list, normally two courses. Students should select their technical electives in the spring of sophomore year to avoid scheduling conflicts. Students should formulate an academic plan for their technical and chemical engineering electives with the assistance of their academic adviser.

Biology

BISC 301	Molecular Biology of the Cell	4
BISC 303	Genetic and Evolutionary Biology	4
BISC 305	Cell Biology	4
BISC 306	General Physiology	4
BISC 4xx	Biology course chosen with the approval of the adviser	3-4

Chemistry

CHEM 333	Organic Chemistry Lab I‡*	2 1
CHEM 334	Organic Chemistry Lab II*	2
CHEM 445	Physical Chemistry Lab I*	1
CHEM 446	Physical Chemistry Lab II*	2
CHEM 457	Inorganic Chemistry	3
CHEM 458	Inorganic Chemistry Lab*	1
CHEM 527	Introductory Biochemistry	3
CHEM 6xx	Chemistry course chosen with the approval of the adviser	3
CHEM 8xx	Chemistry course chosen with the approval of the adviser	3

Computer Science

CISC 300	Introduction to Scientific Computation	3

Mathematics

MATH 349	Elements of Linear Systems	3
MATH 389	Graph Theory	3
MATH 426	Introduction to Numerical Analysis and Algorithmic Computation	3
MATH 428	Algorithmic and Numerical Solution of Differential Equations	3
MATH 5xx	Mathematics course chosen with the approval of the adviser	3
MATH 6xx	Mathematics course chosen with the approval of the adviser	3

Mechanical Engineering Applied Mathematics

MEEG 361	Applied Engineering Analysis	3
MEEG 863	Engineering Analysis I	3
MEEG 864	Engineering Analysis II	3

Physics

PHYS 419	Analytical Mechanics	3
PHYS 6xx	Physics course chosen with the approval of the adviser	3

Statistics

STAT 450	Statistics for the Engineering and Physical Sciences	3
STAT 6xx	Statistics course chosen with the approval of the adviser	3

Electronic Materials

(please note prerequisites)

ELEG 314	Electronics and Instrumentation	4
ELEG 340	Solid State Electronics	3
ELEG 4xx	Solid State Fabrication Laboratory	1
ELEG 623	Electrical Properties of Matter II	3
ELEG 626	Integrated Circuits	3
ELEG 629	Digital Structures	3

Polymeric Materials

MEEG 410	Experimental Mechanics for Composite Materials	3
MEEG 415	Finite Element Analysis	3

Chemical Engineering Technical Electives 9 4

The curriculum provides three chemical engineering technical electives in the senior year. These courses are intended to provide some flexibility in selecting a chemical engineering program at the advanced level. Students should decide with the assistance of their adviser if they should conduct a program of independent research and then choose their course elective(s).

Chemical engineering technical electives are defined as follows. Any Chemical Engineering course numbered between 470 and 499; UNIV 401-UNIV 402 Senior Thesis directed by a Chemical Engineering Faculty; any 600- or 800-level course in Chemical Engineering. Courses at the 600 and 800 level are graduate courses open, with the consent of the instructor, to advanced students in senior standing.

Concentrations

The technical electives and the chemical engineering electives can be coupled to provide a more intense concentration in an area of interest. The groupings below are some examples of this approach.

Biology

BISC 301	Cellular and Molecular Biology	4 3S
CHEM 527	Introductory Biochemistry	3 4F
CHEG 620	Biochemical Engineering	3 4S
CHEG 650	Biomedical Engineering	3 4F

Chemistry

CHEM 457	Inorganic Chemistry	3 3S
CHEM 527	Introductory Biochemistry	3 4F
CHEG 606	Introduction to Catalysis	3 4S
CHEG 610	Industrial and Engineering Chemistry	3 4S
CHEG 836	Applied Chemical Kinetics	3 4F

CREDITS TO TOTAL A MINIMUM OF 130

DEPARTMENTAL STANDARDS

The department has rigorous standards for admission into the courses in the department. These standards have evolved over time and are intended to promote success in

†*Note:* The technical elective program is under constant review by the faculty. An updated list is available in the department office. Students should check with their advisers before selecting courses and should be aware that a formal mechanism exists to provide additional flexibility in selection of their Technical Elective courses. Students should select their technical electives during the spring of the sophomore year to avoid scheduling conflicts. The Technical Electives may be coupled with the Chemical Engineering Technical Electives to obtain a technical concentration.

‡The laboratory lecture CHEM 333(1), Organic Lab Lecture, is required and cannot be counted in this group.

*To encourage students to take labs, any three credit combination of laboratories in inorganic, organic, or physical chemistry may be grouped as a technical elective.

the sequential development of the material. In general students must have a minimum grade of C- in all chemical engineering prerequisite courses to qualify for admission to the next course.

Admission to CHEG 231:
1) A minimum grade of C- in CHEG 112.
2) Coregistration in MATH 243. (It is better to complete MATH 243 before enrolling in CHEG 231.)

Admission to CHEG 325:
1) A minimum grade of C- in CHEG 231.
2) A minimum average of C- in MATH 243.

Admission to CHEG 341:
1) A minimum grade of C- in CHEG 231.
2) A minimum grade of C- in MATH 302.

Admission to CHEG 332:
1) A minimum grade of C- in CHEG 325 or CHEM 444.
2) A minimum grade of C- in MATH 302.

Admission to CHEG 342:
1) A minimum grade of C- in CHEG 341.

Admission to CHEG 345:
1) A minimum grade of C- in CHEG 325.
2) Admission to CHEG 342.

Admission to CHEG 443:
1) A minimum grade of C- in CHEG 342.

Admission to CHEG 445:
1) A minimum grade of C- in CHEG 345.

Admission to CHEG 401:
1) A minimum grade of C- in CHEG 443.

Admission to CHEG 432:
1) A minimum grade of C- in CHEG 332.
2) A minimum grade of C- in CHEG 443.

Graduation Requirements:
1) A "P" (pass) in CHEG 009.
2) A minimum grade of C- in all other Chemical Engineering courses counted towards graduation.

TRANSFER STUDENTS

Students within the University who wish to transfer as sophomores in the fall semester should make a formal request to the Chair by May 1. Unless the case is exceptional, a change-of-major application will only be considered after completion of the following minimum requirement:

1) An overall grade-point index of 2.0.
2) A minimum grade of C- in CHEG 112, Introduction to Chemical Engineering, is required if the course has been taken.
3) A minimum grade of C- in each of the following groups of courses: CHEM 111, CHEM 112, General Chemistry; MATH 241 and 242, Analytic Geometry and Calculus; and PHYS 207, General Physics.

Completion of these minimum requirements does not guarantee admission as a chemical engineering major.

Prospective students who contemplate beginning the program in Chemical Engineering in February, rather than in September, should consult with the Chemical Engineering Department.

Chemical Engineering courses designated by the CHEG prefix are closed to nonmajors. Students seeking exception should contact the Chemical Engineering Department.

CHEMICAL ENGINEERING CURRICULUM—MASTER'S-BACHELOR'S PROGRAM

This four-year program is designed to enable exceptional students with excellent high school backgrounds to obtain a Bachelor of Chemical Engineering degree and a Master of Chemical Engineering degree in four years. This allows students to take maximum advantage of their high school education, gives them a considerable jump over students going the normal bachelor's degree-master's degree route, including a year gained, and reduces redundancy in the total educational program. The program is designed for each individual; the following is considered typical.

The requirements and procedures of the program are:

1) The student is assumed to be qualified for a sufficient amount of credit by advanced placement to omit the entire freshman year on the basis of demonstrated ability in mathematics, chemistry, physics, English and humanities. Certification of the level of the advanced standing is made in the usual way on the basis of CEEB or departmental examinations. CHEG 112, Introduction to Chemical Engineering, is waived upon evidence of suitable self-study.
2) Formal admission to the program and provisional admission to graduate school are provided to students upon request at the end of their second year in the program, or to those who have attained the status of such students, provided an overall grade-point average of at least 3.25 has been attained.
3) If differences exist between graduate and undergraduate fees for a particular student, the undergraduate fee structure applies through the end of the first semester of the third year.
4) Credit toward the B.Ch.E. degree for two technical electives is provided by the graduate-level work. The omitted technical electives would normally be the two senior project (thesis) courses. Thus, the combined program represents a contraction of 9 credits from the normal sequence of a B.Ch.E. degree followed by enrollment in the usual 30-credit graduate program; 6 credits are saved by the student's carrying out only one thesis and the other 3 from waiving CHEG 112, as noted earlier.
5) The program involves a light course load in the final year to enable the student to meet the demands of the graduate thesis at that time.

6) It is desirable for purposes of professional registration that a student be graduated from an accredited undergraduate program and for this reason both degrees (B.Ch.E. and M.Ch.E.) are to be awarded. The student will receive the B.Ch.E. degree upon completion of the third year of the attached sample program with a grade-point average at least 2.0. (This program exceeds the normal credit requirements for a B.Ch.E. degree).

A student who elects to return to a standard B.Ch.E. program and to omit the M.Ch.E. degree will be awarded the B.Ch.E. upon completion of the regular requirements for that degree.

7) To obtain the M.Ch.E. degree the student must meet a grade-point average of at least 3.0 in the 30 credits of graduate work, as usual.

DEGREE: BACHELOR OF CHEMICAL ENGINEERING and MASTER OF CHEMICAL ENGINEERING‡
MAJOR: CHEMICAL ENGINEERING

CURRICULUM		CREDITS*
UNIVERSITY REQUIREMENTS		
ENGL 110	Critical Reading and Writing	3^{1S}
Three credits in an approved course or courses stressing multicultural, ethnic, and/or gender-related content #		3^{1-4}
COLLEGE REQUIREMENTS		
General Education Program		18^{1-4}

See page 207: College General Education Program

MAJOR REQUIREMENTS

External to the College

Biology		
BISC 207	Introductory Biology I	4^{1S}
Chemistry		
CHEM 443	Physical Chemistry	3^{1F}
CHEM 444	Physical Chemistry	3^{1S}
CHEM 331	Organic Chemistry	3^{2F}
CHEM 333	Organic Chemistry Laboratory I	1^{2F}
CHEM 332	Organic Chemistry	3^{2S}
Mathematics		
MATH 243	Analytic Geometry and Calculus C	4^{1F}
MATH 302	Ordinary Differential Equations I	3^{1S}
Physics		
PHYS 208	General Physics	4^{1F}
General Education Program		3^{3-4}

An additional three-credit general education course must be taken in the humanities or social sciences. Furthermore, three of the general education courses (minimum of nine credits) must be in the same department or program, and at least one of these three courses must be above the introductory level. Courses classified as "Group D" by the College of Arts and Science may not be used to fulfill this requirement.

Within the College

MEEG 863	Engineering Analysis I	3^{2F}
MEEG 864	Engineering Analysis II	3^{2S}
MASC 302	Materials Science for Engineers	4^{2F}

Within the Department

CHEG 009	Chemical Engineering Freshman Seminar	0^{1F}
CHEG 112	Introduction to Chemical Engineering Analysis (If not completed by self-study.)	3^{1S}
CHEG 231	Chemical Engineering Thermodynamics	3^{1F}
CHEG 325	Chemical Engineering Thermodynamics	3^{1S}
CHEG 341	Fluid Mechanics	3^{2F}
CHEG 332	Chemical Engineering Kinetics	3^{2F}
CHEG 345	Chemical Engineering Laboratory I	3^{2S}
CHEG 342	Heat and Mass Transfer	3^{2S}
CHEG 443	Mass Transfer Operations	3^{3F}
CHEG 445	Chemical Engineering Laboratory II	3^{3F}
CHEG 825	Chemical Engineering Thermodynamics	3^{3F}
CHEG 401	Chemical Process Dynamics and Control	3^{3S}
CHEG 432	Chemical Process Analysis	3^{3S}
CHEG 835	Applied Chemical Kinetics	3^{3S}
CHEG 863	Diffusional Operations	3^{3S}
CHEG	Graduate Electives	$12^{3,4}$
CHEG 830	Fluid Mechanics	3^{4F}
CHEG 869	Master's Thesis	6^{4}

CIVIL ENGINEERING

All divisions of engineering trace their ancestry back to civil engineering. "Civil" was originally used to identify engineering endeavors unrelated to military activities. Because of its origin and history, civil engineering embraces a wide variety of technological areas.

Traditionally, civil engineering has been identified with the planning and design of constructed facilities such as dams, bridges, buildings, transportation networks, harbors, waterways, and tunnels. Civil engineering still encompasses constructed facilities as an important activity, and our students are supplied with a solid background for working in areas such as structural engineering, soil mechanics, and hydraulics. However, modern civil engineering has expanded into a variety of other areas and deals with large proportions of the infrastructure of modern industrialized societies including cities, highways and traffic control, mass transportation systems, utilities networks, irrigation systems, water resources exploration and management, environmental protection facilities, coastal management and protection works, and offshore structures. As the country rebuilds these facilities, the Civil Engineer is the central professional involved. Civil engineers are rapidly becoming of central importance to developing countries as well.

*Superior figures indicate semester (fall or spring) and/or year or years in which the course is normally taken, i.e., ^{1F}fall of freshman year, ^{2S}spring of sophomore year, etc.
#This requirement may be fulfilled through a course taken to complete major, group, breadth, or elective requirements. See page 20.
‡This curriculum assumes that the following courses have been granted by advanced placement or the equivalent. It is necessary to have 28-30 credits of advanced placement to participate in the program outlined above. The schedule will be adjusted for the accomplishments of the student by the faculty adviser.
AP Chemistry–8 credits, AP Calculus–8 credits, AP Physics–4 credits, AP English–6 credits, AP Computer Science–3 credits.

Today's society also requires civil engineers to be sensitive to, and aware of, the impact that proposed engineering solutions will have on people and the natural environment. Applying technical competence to problems that are central to society's environmental needs and concerns represents challenges and opportunities for civil engineers.

To meet these challenges, the Civil Engineering Department offers a program with a balanced content varying from the fundamental disciplines to practical engineering methods. Students during the first semester begin to solve civil engineering problems on computers using mathematics and science. Throughout the four year curriculum, the Department emphasizes the application of the methods of engineering science to civil engineering problems and gradually upgrades students' analytical and computational skills to satisfy the needs of the engineering courses. Additionally, a total of six courses of the program are devoted to studies in the humanities and social sciences with the objective of developing a base for the human and social aspects of the engineering profession. This curriculum of required core courses provides a background in the entire field of civil engineering. The emphasis on developing a sound theoretical foundation also provides a basis for continual learning throughout students' professional careers.

In the junior and senior year, there is opportunity to gain a deeper insight into one of the civil engineering disciplines through a number of technical electives. A wide variety of courses are available for this part of the program. Below, under the heading of Technical Electives, are listed some courses that, together with the required course curriculum, will give an in-depth knowledge in each of the listed areas.

DEPARTMENTAL REGULATIONS

To be enrolled in 300- or 400-level civil engineering or mechanics courses, civil engineering majors must have attained at least a C grade in the following courses: CHEM 103, CHEM 104, MATH 241, MATH 242, and PHYS 207. If courses are retaken to meet this requirement, only the most recent grade received in any given course will be used in computing the average for the purposes of this requirement.

Students also must have a 2.0 grade-point average in all required courses in mathematics, the sciences, and engineering. If courses are retaken to meet this requirement, only the most recent grade received in any repeated course will be used by the department in computing the average.

In general, 300- and 400-level courses in civil engineering are open only to Civil Engineering majors. Students who have declared a Civil Engineering Minor and students enrolled in other departments in the College of Engineering who wish to take civil engineering courses as technical electives can, with the approval of their home department adviser, be enrolled in 300- or 400-level courses in the Civil Engineering Department. In some instances, others may be permitted to enroll in selected 300- and 400-level courses, but they must have the permission of both the course instructor and the chair of the Civil Engineering Department.

DEGREE: BACHELOR OF CIVIL ENGINEERING
MAJOR: CIVIL ENGINEERING

CURRICULUM		CREDITS*
UNIVERSITY REQUIREMENTS		
ENGL 110	Critical Reading and Writing	3^{1S}
Three credits in an approved course or courses stressing multicultural, ethnic, and/or gender-related content.#		3^{1-4}
COLLEGE REQUIREMENTS		
General Education Program		18^{1-4}
See page 207: College General Education Program.		
MAJOR REQUIREMENTS		
External to the College		
ENGL 410	Technical Writing	3^{4S}
Chemistry		
CHEM 103	General Chemistry	4^{1F}
CHEM 104	General Chemistry	4^{1S}
CISC 106	General Computer Science for Engineers	3^{2F}
GEOL 107	General Geology I	4^{2F}
STAT 450	Statistics for the Engineering and Physical Sciences	3^{3S}
Mathematics		
MATH 241	Analytic Geometry and Calculus A	4^{1F}
MATH 242	Analytic Geometry and Calculus B	4^{1S}
MATH 243	Analytic Geometry and Calculus C	4^{2F}
MATH 302	Ordinary Differential Equations I	3^{2S}
Physics		
PHYS 207	General Physics	4^{1S}
PHYS 208	General Physics	4^{2S}
Within the College		
CIEG 125	Introduction to Engineering (CE)	2^{1F}
EGGG 132	Engineering Graphics/Analysis	2^{1F}
MASC 302	Material Science for Engineers	4^{3F}
MECH 305	Fluid Mechanics	3^{3S}
MECH 306	Fluid Mechanics Laboratory	1^{3S}
Within the Department		
CIEG 211	Statics	3^{2F}
CIEG 212	Strength of Materials	3^{2S}
CIEG 213	Materials Laboratory I	1^{2S}
CIEG 301	Analysis of Structures	4^{3F}
CIEG 311	Dynamics	3^{3F}
CIEG 331	Introduction to Environmental Engineering	3^{3F}
CIEG 351	Transportation Engineering	3^{3S}
CIEG 381	Civil Engineering Analysis	3^{3S}
One of:		
CIEG 402	Steel Design	3^{4F}
or		
CIEG 403	Concrete Design	3
CIEG 420	Soil Mechanics	4^{4F}

*Superior figures indicate semester (fall or spring) and/or year or years in which the course is normally taken, i.e., ^{1F}fall of freshman year, ^{2S}spring of sophomore year, etc.
#This requirement may be fulfilled through a course taken to complete major, group, breadth, or elective requirements. See page 26.

One of:		
CIEG 431	Water Supply Engineering	3 4S
or		
CIEG 432	Wastewater Engineering	3
One of:		
CIEG 441	Hydrology	3 4F
or		
CIEG 442	Hydraulic Engineering	3
CIEG 461	Senior Design Project	3 4S
CIEG 482	System Design and Operation	3 4F

Technical Electives†

Technical Electives
Four courses: Three additional design points must be satisfied; see current department technical elective listing.

CREDITS TO TOTAL A MINIMUM OF 131

TECHNICAL ELECTIVES

The Civil Engineering curriculum contains four technical elective courses that give students the opportunity to complete their education by concentrating in an area of special interest.

The required course curriculum provides the basis in mathematics, science, the applied engineering sciences, and engineering design that students need for future work and enhances their general education background. However, it only gives students an introduction to each of the major areas of civil engineering offered by the program: Structural Engineering and Soil Mechanics, Environmental Engineering and Water Resources, Hydraulics and Ocean Engineering, and Transportation Engineering.

The following are suggestions for courses to choose from if the student wants to concentrate in one of the above mentioned areas or wants a general civil engineering degree that further supports the breadth of the required course curriculum.

GENERAL CIVIL ENGINEERING

CIEG 223	Surveying
CIEG 401	Computer Methods of Structural Engineering
CIEG 402	Steel Design
CIEG 403	Concrete Design
CIEG 421	Foundations and Substructures
CIEG 431	Water Supply Engineering
CIEG 432	Wastewater Engineering
CIEG 441	Hydrology
CIEG 442	Hydraulic Engineering
CIEG 452	Transportation Facilities Design
CIEG 471	Introduction to Coastal Engineering
EGGG 432	Principles of Computer-Aided Drawing

ENVIRONMENTAL ENGINEERING

CIEG 403	Concrete Design
CIEG 4xx	Environmental Engineering Laboratory
CIEG 421	Foundations and Substructures
CIEG 431	Water Supply Engineering
CIEG 432	Wastewater Engineering
CIEG 441	Hydrology
CIEG 442	Hydraulic Engineering
CIEG 4xx	Hazardous Waste Management
AGEG 628	Land Application of Wastes
BISC 371	Introduction to Microbiology
BISC 472	Principles of Infectious Diseases
BISC 641	Microbial Ecology
CHEM 213	Elementary Organic Chemistry
CHEM 214	Elementary Biochemistry
CHEM 220	Quantitative Analysis
CHEM 418	Introduction to Physical Chemistry
ELEG 681	Remote Sensing in Environment
GEOL 413	Fundamental Well Logging
GEOL 421	Environmental and Applied Geology
GEOL 428	Hydrogeology
MEEG 307	Thermodynamics I

HYDRAULIC AND OCEAN ENGINEERING

CIEG 441	Hydrology
CIEG 421	Foundations and Substructures
CIEG 422	Earth Structures Engineering
CIEG 431	Water Supply Engineering
CIEG 401	Computer Methods of Structural Engineering
CIEG 403	Concrete Design
CIEG 471	Introduction to Coastal Engineering
CIEG 442	Hydraulic Engineering
MEEG 361	Applied Engineering Analysis

STRUCTURES AND GEOTECHNICAL ENGINEERING

CIEG 223	Surveying
CIEG 401	Computer Methods of Structural Analysis
CIEG 402	Steel Design
CIEG 403	Concrete Design
CIEG 404	Structural Engineering
CIEG 414	Structural Dynamics Design
CIEG 415	Reliability Design
CIEG 416	Random Vibration
CIEG 417	Advanced Structural Analysis
CIEG 418	Continuously Supported Structures
CIEG 421	Foundations and Substructures
CIEG 422	Earth Structures Engineering
CIEG 459	Railroad Engineering
CIEG 467	Prestressed Concrete
CIEG 467	Structural Materials
CIEG 486	Engineering Management

TRANSPORTATION ENGINEERING

CIEG 223	Surveying
CIEG 452	Transportation Facilities Design
CIEG 454	Urban Transportation Planning
CIEG 459	Railroad Engineering
CIEG 486	Engineering Management
GEOG 328	Transportation Geography
STAT 420	Data Analysis and Nonparametric Statistics

TRANSFER STUDENTS

Students wishing to transfer into the Department of Civil Engineering from other colleges outside the University are considered along with freshman applicants unless it is judged that they have completed sufficient work to be able to finish their engineering program in three years or less. Candidates for admission as sophomores or juniors will be considered in competition with students transferring internally at the University of Delaware. Successful

†The technical elective program is under constant review by the faculty. An updated list is available in the department office. Students should check with their advisers before selecting courses and should be aware that a formal mechanism exists to provide additional flexibility in the selection of their technical elective courses.

transfer applicants will have a good record, maintaining at least a "B" average overall and in math, science, and engineering courses taken during their last year as a full-time student.

Students wishing to transfer internally into the Department of Civil Engineering from other departments or colleges within the University of Delaware must have at least sophomore status and have completed MATH 241, 242, CHEM 103, 104 and PHYS 207 with a grade of "C" or better and must have maintained at least an overall average of "B" during their last year as a full-time student. To initiate a request for transfer, a change of major form must be turned in to the department prior to May 1 for fall admission and prior to December 1 for spring admission. Compliance with the minimum requirements does not guarantee acceptance for transfer.

MINOR IN CIVIL ENGINEERING

A minor in civil engineering may be earned by a student in any University bachelor's degree program through successful completion of a minimum of 21 credits in civil engineering and engineering mechanics in accord with the following list and requirements. In addition, before beginning the civil engineering courses, the student must have credit for MATH 241, 242 and PHYS 207; must meet the usual course prerequisites; must complete successfully, CHEM 103, 104, MATH 243, 302 and PHYS 208 before being certified for the minor in civil engineering; and must have a 2.0 average in the 21 credits of the civil engineering minor and in the eight mathematics and science courses listed above.

The required engineering courses are:

Statics, CIEG 211	3
Strength of Materials, CIEG 212 (Lab optional)	3
Dynamics, CIEG 311	3
Fluid Mechanics, MECH 305 (Lab optional)	3

Further, an additional 9 credits (3 courses) in civil engineering must be taken of which at least 6 credits must be at the 300 or higher level. Those courses shall be selected with the specific advice of an adviser in the Civil Engineering Department to meet each student's objectives. For students oriented toward earth sciences these might include CIEG 420 and CIEG 421; for those interested in the environment, CIEG 331 and 431; for those interested in urban topics, CIEG 331 and 351; for those with interests in construction and structures, CIEG 301, 303 and 402 or 403; for those interested in the oceans, CIEG 442, and CIEG 471.

Accomplishment of a minor in civil engineering has many advantages for students who are earning degrees in other sciences such as geology or in other professional areas such as business administration, but it must be understood that meeting the requirements for a minor in civil engineering without fulfilling the remaining requirements for an accredited engineering degree will not satisfy many employers seeking engineering employees, nor will it satisfy state licensing and registration boards that examine and certify people as professional engineers and engineers-in-training. A minor in civil engineering does not bestow the breadth and depth of knowledge required to be a civil engineer.

ELECTRICAL ENGINEERING

Electrical engineering is one of the largest of the professions and among the most varied. It involves energy and information and their control, transformation and distribution. It is based on the electrical and information sciences and the related field of materials science. Electrical engineering as a profession has been recognized since the development of telegraphy before the Civil War. It has since grown to include power systems, telephony, electronics, radio, communications systems, computers, microelectronics, lasers and fiber optics, solar electric energy, and many other related areas.

Just as electrical engineering has continually grown in scope and changed emphasis in the past, we can expect change in the future. To prepare today's students for a lifetime of productive engineering, the Delaware program emphasizes the basics; that is, basic mathematics and science and the equally important basic principles of engineering analysis and design. To the study of the basics, the Delaware electrical engineering program adds in-depth study of an area or areas of current practice.

The Delaware electrical engineering program is different from many others in that students are admitted as "electrical engineering students". Coursework in electrical engineering starts with the first term of the freshman year. An advantage of this arrangement is that with four years of electrical engineering courses the program flows better, and better use is made of prerequisite courses. In addition, the size of the electrical engineering class can be limited, which in turn allows a program with many more courses with laboratories.

There are three basic parts to the Delaware curriculum in electrical engineering: (1) a core group of technical courses; (2) an elective group of technical courses in an area of concentration; and (3) a "general education" component that includes six courses in the humanities and social sciences and two in written communications.

The core group includes four courses in mathematics (starting with the **second** calculus course, MATH 242), two in physics, one in chemistry, two in computer science, and sixteen in electrical engineering.

The technical electives must be chosen to form an area of concentration. Four examples of acceptable concentrations (emphasizing computer engineering, systems and signals, devices and materials, and power systems) are shown on the following pages. In planning their technical elective programs, students must also consider the

requirement for a design course in the senior year in which one design project is at least 50% of the course work.

The general education program must include courses from the humanities and from the social sciences, including courses at an advanced level. Electrical engineering students must include a course in microeconomics, two writing courses (ENGL 110 and ENGL 301), and a one-credit course in ethics (PHIL 341).

DEPARTMENTAL REQUIREMENTS

To qualify for sophomore standing, students must have satisfactorily completed MATH 242-243, CISC 180-181, CHEM 103, PHYS 207, and ELEG 210-211 by the end of the summer session of their freshman year. With few exceptions, electrical engineering students are expected to complete the program in eight regular semesters. With electrical engineering courses being offered only once each year, it is imperative that students follow as closely as possible the course sequence outlined in the following pages.

DEGREE: BACHELOR OF ELECTRICAL ENGINEERING
MAJOR: ELECTRICAL ENGINEERING

CURRICULUM		CREDITS*
UNIVERSITY REQUIREMENTS		
ENGL 110	Critical Reading and Writing	3^{1S}
Three credits in an approved course or courses stressing multicultural, ethnic, and/or gender-related content #		3^{4}
COLLEGE REQUIREMENTS		
General Education Program		18^{1-4}

See page 207: College General Education Program.

MAJOR REQUIREMENTS

External to the College

ENGL 301	Problems in Composition	3^{3F}
PHIL 341	Ethics of Engineering Profession	1^{4F}
Mathematics		
MATH 242	Analytic Geometry and Calculus B†	4^{1F}
MATH 243	Analytic Geometry and Calculus C	4^{1S}
MATH 341	Differential Equations with Linear Algebra I	3^{2F}
MATH 342	Differential Equations with Linear Algebra II	3^{2S}
Chemistry		
CHEM 103	General Chemistry	4^{1F}
Physics		
PHYS 207	General Physics	4^{1S}
PHYS 208	General Physics	4^{2F}
Computer Science		
CISC 180	Introduction to Computer Science I	3^{1F}
CISC 181	Introduction to Computer Science II	3^{1S}

Within the Department

ELEG 210	Introduction to Combinational Logic	2^{1F}
ELEG 211	Introduction to Sequential Circuits	2^{1S}
ELEG 205	Linear Circuit Theory	4^{2F}
ELEG 220	Microprocessor Based Systems I	2^{2F}
ELEG 309	Electronic Circuit Analysis I	4^{2S}
ELEG 221	Microprocessor Based Systems II	2^{2S}
ELEG 302	Electrical Properties of Materials	4^{2S}
ELEG 305	Signal Processing I	3^{3F}
ELEG 312	Electronic Circuit Analysis II	4^{3F}
ELEG 320	Field Theory I	3^{3F}
ELEG 306	Signal Processing II	4^{3S}
ELEG 310	Random Signals and Noise	3^{3S}
ELEG 340	Solid State Electronics	3^{3S}
ELEG 417	Feedback Control Systems	3^{4F}
ELEG 413	Field Theory II	4^{4S}
ELEG 433	Energy Systems	3^{4S}

Note: ELEG 310 may be taken in the senior year(s) and ELEG 413 and/or ELEG 433 in the junior year(s) when appropriate to a plan for a technical concentration.

Design Requirement

In addition to the design content of the normal program, every student must take at least one course in the senior year in which one design project is at least 50% of the coursework. Regularly offered courses that presently meet this requirement are ELEG 420, 422, 650 and 664. Other special courses are offered that will meet this requirement. The design requirement may also be met with special projects carried out in conjunction with faculty research with the prior approval of the Departmental Undergraduate Representative. Students must consult with their advisers for the proper selection of design courses.

Technical Electives

Technical Electives‡ ..... 21^{2-4}

Each student must select a concentration to structure his/her technical elective program. Four concentrations are now defined (computer engineering, systems and signals engineering, electronic devices and materials engineering and power systems engineering). Students with a special interest may define their own concentrations in conjunction with their adviser. With some exceptions, upper-level engineering, computer science, physics, science and mathematics courses are acceptable technical electives. However, students planning their own programs of concentration should realize that there must be a theme holding together at least most of the courses chosen. Any special concentrations must be approved by the Departmental Undergraduate Representative prior to the start of the senior year.

Each of the four regular concentrations specifies 15, or more, of the 21 technical elective credits in the core program. Students should note that the requirement for a senior design project will, in some cases, further constrain the choice of technical electives.

The technical electives must be chosen from an area of concentration. The four concentrations follow:

*Superior figures indicate semester (fall or spring) and/or year or years in which the course is normally taken, i.e., ^{1F}fall of freshman year, ^{2S}spring of sophomore year, etc.
#This requirement may be fulfilled through a course taken to complete major, group, breadth, or elective requirements. See page 26.
†MATH 242 is the first mathematics course in our regular program. It is the incoming student's responsibility to assess his/her own mathematics background and proficiency (using materials supplied by our Math Department). If you are not ready to start with MATH 242, you must take MATH 241 (and possibly other earlier mathematics courses). If you have had some calculus, but are not certain that you are ready for MATH 242, start with MATH 242. In this case it is easy to drop back to MATH 241 after a few weeks of MATH 242 if this is where you belong. If you need additional mathematics, at least one Winter and/or Summer sessions course will be required to complete the four year electrical engineering program on schedule. To remain on schedule with your program, you must be on schedule in mathematics by the start of the sophomore year.
‡The technical elective program is under constant review by the faculty. An updated list is available in the department office. Students should check with their advisers before selecting courses and should be aware that a formal mechanism exists to provide additional flexibility in the selection of their technical elective courses.

Technical Electives—Computer Engineering

CISC 220	Data Structures	3 3F
CISC 360	Computer Architecture	3 3S
ELEG 323	Digital System Design I	3 3S
ELEG 422	Digital System Design II	3 4F
ELEG 618	Modern Control Engineering	3 4S
or		
ELEG 631	Digital Signal Processing	3 4F
Technical electives chosen with the approval of an adviser		6 4

Technical Electives—Systems and Signals Concentration

CISC 220	Data Structures	3 2S
MATH 426	Introduction to Numerical Analysis and Algorithmic Computation	3 3F
ELEG 403	Communication Systems Engineering	3 4F
ELEG 618	Modern Control Engineering	3 4S
ELEG 631	Digital Signal Processing	3 4F
Technical electives chosen with the approval of an adviser		6 4

Technical Electives—Devices and Materials Concentration

Students whose primary interest is in the Devices and Materials Engineering concentration should take:

PHYS 209	General Physics	3 2S
PHYS 313	Physical Optics	4 3S
ELEG 623	Electronic Properties of Matter	3 4F

Students whose primary interest is in optoelectronics and electro-optics should take:

ELEG 640	Optoelectronics	3 4F
and		
ELEG 642	Special Topics in Electrooptics**	3 4S

Students whose primary interest is in electronic devices should take:

ELEG 626	Integrated Circuits	3 4F
and		
ELEG 650	Semiconductor Device Design and Fabrication**	3 4S
Technical electives chosen with the approval of an adviser		6 4

Technical Electives—Power Systems Concentration

MEEG 307	Thermodynamics I	3 3F
ELEG 412	Introduction to Power Systems Analysis	4 4F
ELEG 414	Electrical Machines, Motors and Generators	4 4S
ELEG 618	Modern Control Engineering	3 4S
MEEG 408	Power Generation System Design	3 3S
or		
ELEG 323	Digital Systems Design I	3 3S
Technical electives chosen with the approval of an adviser		6 4

CREDITS TO TOTAL A MINIMUM OF **128**

TRANSFER STUDENTS

Transfer students by definition fall into two categories. Regular transfer students are those students who have obtained college or university course credits after completion of high school, but who cannot be expected to complete their degrees in less than four years. These students will be considered for admission along with normal applicants for the freshman class and will be selected by the Admissions Office. The criteria for admission will be the same as used for all other freshman applicants.

Transfer students with advanced standing in electrical engineering are those students with enough appropriate math, science and engineering transfer credits who can be expected to complete their degrees with three or fewer years of additional study. This group includes both students from other programs at the University as well as those from other colleges and universities. The admission of these students will be decided by the faculty of the electrical engineering department and will be determined by the number of student slots available and the student's record in math, science and engineering courses as well as his or her overall academic record.

The above guidelines are provided as general information for transfer applicants. The department's detailed transfer policy is available from the departmental office in 140 Evans Hall.

MECHANICAL ENGINEERING

Mechanical engineers receive one of the broadest educations of any of the modern engineering disciplines and consequently are well prepared to apply basic engineering principles to a wide variety of society's needs. Some of the many challenging fields requiring the talents of mechanical engineers in both the design and development of new technology are energy, environmental engineering, manufacturing, exploration and use of the space environment and the oceans, materials engineering, medical technology, and transportation.

Since many technologies will reach their zenith and wane in less than the duration of an individual's career, mechanical engineers must have a firm foundation in the more basic and durable engineering sciences to be able to adapt and contribute to new and evolving fields. The educational program set out below has been carefully structured around a basic core program that will enable the Bachelor of Mechanical Engineering graduate to follow many career paths, including research, development, design, production, maintenance, management, patent law, or education. However, the curriculum also allows a student to select engineering fields of particular interest for study, such as aerospace, materials, biomechanics, controls, design and systems, robotics, energy, and fluids.

The degree course is designed to serve not only those students who go into industry or government directly after the B.M.E. degree, but also those who go on to a graduate program in engineering or continue their education in other professions such as medicine, law or business administration. The commitment by the faculty to student advisement, in combination with the curriculum flexibility offered by the technical electives, results in a program that can be optimized for an individual's needs, talents and aspirations.

**Courses must be taken as a sequence, ELEG 640 and ELEG 642 or ELEG 626 and ELEG 650.

The Mechanical Engineering department contains modern research and teaching laboratories, a fully equipped machine shop and a laboratory dedicated to computer-aided-engineering. Undergraduates are encouraged to participate in research projects with faculty and graduate students involving the use of state-of-the-art instrumentation, electronics and computers. The computer facilities available for student use include networked microcomputers, a department Vax network with color graphics, and a variety of university main frames. Laboratory space is set aside exclusively for student project work.

TECHNICAL ELECTIVE PROGRAM

Technical electives in the senior year of the Bachelor of Mechanical Engineering curriculum provide the student with an opportunity to pursue areas of particular interest. The technical electives are taken after much of the basic engineering science has been mastered and comprise four coordinated courses (a minimum of 12 credits). Although the majority of the available electives are drawn from the Mechanical Engineering department, courses at the 400 level and above from other departments and colleges can be selected with the adviser's approval.

There are four suggested major areas of concentration, Aerospace Engineering, Fluids and Thermal Engineering, Solid Mechanics and Materials, and Design, Dynamics and Manufacturing. However, technical elective programs can be structured to meet individual interests and students are encouraged to discuss their educational objectives with their adviser early in the junior year and to develop an agreed selection of technical electives.

DEPARTMENTAL ACADEMIC STANDARDS

To enroll in the required fourth-semester courses—MEEG 214, MEEG 313 and MASC 302—the student must meet the following standards:

a. an overall grade-point average of 2.0

b. a grade of C or better in the courses MEEG 125, MATH 243, CHEM 104, PHYS 207 and MEEG 213.

Student's progress and academic records are reviewed each semester to enforce departmental standards.

DEGREE: BACHELOR OF MECHANICAL ENGINEERING
MAJOR: MECHANICAL ENGINEERING

CURRICULUM	CREDITS*
UNIVERSITY REQUIREMENTS	
ENGL 110 Critical Reading and Writing	3^{1F}
Three credits in an approved course or courses stressing multicultural, ethnic, and/or gender-related content.#	3^{1-4}
COLLEGE REQUIREMENTS	
General Education Program	18^{1-4}
See page 207: College General Education Program.	
MAJOR REQUIREMENTS	
External to the College	
An additional course (minimum of three credits) that can be either Air Force ROTC or a course outside the College of Engineering (not including mathematics or science or courses in the "Group D" classification of the College of Arts and Science).	3^{1-4}
Chemistry	
CHEM 103 General Chemistry	4^{1F}
CHEM 104 General Chemistry	4^{1S}
Mathematics	
MATH 241 Analytic Geometry and Calculus A	4^{1F}
MATH 242 Analytic Geometry and Calculus B	4^{1S}
MATH 243 Analytic Geometry and Calculus C	4^{2F}
MATH 302 Ordinary Differential Equations I	3^{2S}
Physics	
PHYS 207 General Physics	4^{1S}
PHYS 208 General Physics	4^{2F}
Within the College	
MEEG 125 Introduction to Engineering (MEEG)	3^{1F}
EGGG 132 Engineering Graphics/Analysis	2^{1S}
MASC 302 Material Science for Engineers	4^{2S}
MECH 305 Fluid Mechanics	3^{3F}
MECH 306 Fluid Mechanics Laboratory	1^{3F}
ELEG 314 Electronics and Instrumentation	4^{4F}
Within the Department	
MEEG 213 Principles of Mechanics I	3^{2F}
MEEG 214 Principles of Mechanics II	3^{2S}
MEEG 307 Thermodynamics I	3^{3F}
MEEG 308 Thermodynamics II	3^{3S}
MEEG 313 Strength of Materials	4^{2S}
MEEG 316 Materials Engineering	3^{3F}
MEEG 347 Mechanical Design I	3^{3F}
MEEG 348 Mechanical Design II	3^{3S}
MEEG 361 Applied Engineering Analysis	3^{3F}
MEEG 391 Engineering Science Laboratory I	4^{3S}
MEEG 336 Fluid Mechanics II	3^{3S}
MEEG 302 Heat Transfer	3^{3S}
MEEG 427 System Dynamics I	3^{4F}
MEEG 447 Design and Systems Synthesis I	3^{4F}
MEEG 448 Design and Systems Synthesis II	3^{4S}
Technical Electives	
Technical Electives†	12^{4}
400-level or above courses in engineering, science or mathematics selected by the student with the approval of their adviser.	
There are four suggested areas of concentration in the technical elective offerings. Students should select a minimum of 12 credits from the following courses or substitute other courses in consultation with their adviser.	
I. Aerospace Engineering	
MEEG 411 Structural Mechanics for Mechanical and Aerospace Engineering	3
MEEG 413 Advanced Mechanics of Materials	3
MEEG 415 Finite Element Analysis	3
MEEG 432 Aerodynamics	3

*Superior figures indicate semester (fall or spring) and/or year or years in which the course is normally taken, i.e., ^{1F}fall of freshman year, ^{2S}spring of sophomore year, etc.
#This requirement may be fulfilled through a course taken to complete major, group, breadth, or elective requirements. See page 26.
†Students are encouraged to develop a technical elective program that meets their own interests and career plans, but all technical elective selections must be approved by an adviser.

MEEG 435	Propulsion	3
MEEG 436	Fluid Machinery	3
MEEG 445	Senior Research	3-6
MEEG 616	Composite Materials Structures	3
II. Fluids and Thermal Engineering		
MEEG 408	Power Generation System Design	3
MEEG 432	Aerodynamics	3
MEEG 435	Propulsion	3
MEEG 436	Fluid Machinery	3
MEEG 4xx	Flow of Viscous Materials	3
MEEG 445	Senior Research	3-6
MEEG 6xx	Composite Manufacturing	3
III. Solid Mechanics and Materials		
MEEG 411	Structural Mechanics for Mechanical and Aerospace Engineering	3
MEEG 413	Advanced Mechanics of Materials	3
MEEG 415	Finite Element Analysis	3
MEEG 4xx	Flow of Viscous Materials	3
MEEG 445	Senior Research	3-6
MEEG 616	Composite Materials Structures	3
MEEG 617	Composite Materials	3
MASC 602	Structure of Materials	3
MASC 615	Mechanical Properties of Materials	3
IV. Design, Dynamics and Manufacturing		
MEEG 408	Power Generation System Design	3
MEEG 415	Finite Element Analysis	3
MEEG 445	Senior Research	3-6
MEEG 625	Vehicle Dynamics	3
MEEG 663	Computer Aided Design	3
MEEG 6xx	Composite Manufacturing	3
MEEG 6xx	Design with Composites	3
MEEG 6xx	Design of Composites	3
CREDITS TOTAL A MINIMUM OF		**131**

TRANSFER STUDENTS

Students who wish to transfer into the Department of Mechanical Engineering from outside the college but within the University should apply to the chair by May 1 and complete a Change of College/Major/Degree form. Because of the large enrollment in the department, the following guidelines have been established for students wishing to transfer into the department:

1. Completion of MATH 241, MATH 242, PHYS 207, CHEM 103‡ and CHEM 104‡ with a grade of C or better in each course.
2. An overall grade-point index above the median of the freshman class (currently 2.5).

These admission criteria are minimum standards, and more stringent requirements may be imposed by enrollment limitations. In any case, admission depends on there being enrollment openings in the class for which the student is applying. Generally, the guidelines specified by the College Transfer Policy will be followed to initiate and process transfer applicants (see page 208). This general transfer policy should be reviewed carefully by all applicants.

‡CHEM 111, 112 and 119 are acceptable substitutes.

Students should also be aware that by taking MEEG courses beyond those listed as required for transfer, they are not guaranteed candidacy for the Bachelor of Mechanical Engineering. Efforts to control class size and total enrollment in the department have required that nonmajors be administratively removed from class lists following the registration period. Faculty teaching junior and senior courses are instructed not to admit nonmajors during the drop/add period.

DEPARTMENT OF AIR FORCE ROTC

The Air Force Reserve Officer Training Corps (AFROTC) provides a program for college men and women to earn commissions as Second Lieutenants in the United States Air Force while completing their University course requirements. Commissioning follows the award of a University bachelor's degree.

PROGRAMS OFFERED

Four-Year Program. The four-year program is composed of a General Military Course (GMC) and a Professional Officer Course (POC). The first two years, the GMC, provide a general introduction to the Air Force and the various career fields. Students enrolled in the GMC who are not receiving an Air Force Scholarship incur no reserve or active duty service obligation to the Air Force and may elect to discontinue the program at any time. The final two years, the POC, concentrate on developing leadership and management skills and on a study of American defense policy. Students must compete for entry into the POC. If accepted, they must attend four weeks of field training at a designated Air Force base during the summer following their sophomore year of college. When they return to the University in the Fall, they are placed under contract with the Air Force to complete the program and serve a minimum of four years on active duty. Pilot and navigator candidates incur an additional obligation because of specialized training following commissioning. All students under contract receive approximately $1,000 tax free annually.

Two-Year Program. The two-year program is normally offered to prospective juniors and graduate students. The academic requirements for this program are identical to the final two years of the four-year program. During the summer preceding entry into the two-year program, all candidates must complete a six-week field training session at a designated Air Force base.

General Requirements for POC Acceptance. Students competing for acceptance as POC cadets must complete the four-year or two-year program prerequisites, pass the Air Force Officer Qualifying Test, be physically qualified, meet certain age requirements, and be in good academic standing.

THE CURRICULUM

General Military Course (GMC)

Freshman year: The Development of Air Power I/II—AFSC 100 (fall) and AFSC 101 (spring). Each of these one-credit courses consists of approximately one hour of academic class and one-and-a-half hours of leadership laboratory each week. These two GMC courses survey the history of air power from the 18th century to the present.

Sophomore year: The Air Force Today I/II—AFSC 200 (fall) and AFSC 201 (spring). Each of these one-credit courses consists of approximately one hour of academic class and one-and-a-half hours of leadership laboratory each week. In combination, these two courses survey the roles of the Department of Defense and the U.S. Air Force in our society.

GMC courses are open to all freshman and sophomore students. Only those interested in entering the POC attend the leadership laboratories.

Professional Officer Course (POC)

Junior year: Leadership and Management I/II—AFSC 310 (fall) and AFSC 311 (spring). Each of these three-credit courses consists of two-and-a-half hours of academic classes and two hours of leadership laboratory each week. Here the student is introduced to leadership and management concepts. The courses are designed to provide a foundation for basic leadership and management skills, with emphasis on communications.

Senior year: National Security Forces in U.S. Society I/II—AFSC 410 (fall) and AFSC 411 (spring). Each of these three-credit courses consists of two-and-a-half hours of academic classes and two hours of leadership laboratory each week. These courses focus on our national security policy—its evolution, actors, processes, and current issues. Emphasis is also given to military professionalism, military justice, and communication skills.

POC courses are open to all juniors and seniors without regard to enrollment in the AFROTC program. Only the POC cadets attend the leadership laboratories.

Scholarships Available. The AFROTC College Scholarship Program provides four- to eight-semester scholarships to students on a competitive basis. Scholarships are available in technical and nontechnical fields and are based on the whole-person concept. Any University of Delaware student may apply for these scholarships. Opportunity for scholarship selection is enhanced by enrolling in AFROTC. Those selected receive full tuition, lab expenses, incidental and textbook fees, plus a $100 monthly, nontaxable allowance during the school year. Students who accept a scholarship enter the AFROTC program as a contract cadet.

Air Force ROTC Nurse Program. Air Force ROTC makes it possible for qualified nursing school applicants to enroll in its programs and, upon completion of all academic requirements, receive a commission as a Second Lieutenant in the United States Air Force Medical Corps. Four- to eight-semester scholarships are available to highly qualified applicants.