Graduates of the B.S. curricula offered by the college may enter directly into a position in industry, government, or private practice, or may pursue advanced study in graduate school. Their professional activities include research, development, design, operations analysis, construction, production supervision, and technical sales. Many practice their profession in Tennessee; but engineering knows no geographical bounds, and graduates of the college serve throughout the nation and in other countries as well.

The college, in cooperation with industrial sponsors, established the Minority Engineering Scholarship Program in 1973. The program goal is to increase significantly the number of qualified minority engineering graduates.

The college has eleven major undergraduate curricula in which a student may specialize: aerospace engineering, biomedical engineering, chemical engineering, civil engineering, computer engineering, electrical engineering, industrial engineering, materials science and engineering, mechanical engineering, nuclear engineering, and engineering physics.

Biosystems engineering is based in the College of Agricultural Sciences and Natural Resources with facilities located on the Agricultural Campus. The biosystems engineering curriculum is offered cooperatively by the College of Agriculture and the College of Engineering. Details of the curriculum may be found in the College of Agricultural Sciences and Natural Resources section of this catalog.

Most of the college’s facilities are on the southeastern corner of The Hill. Administration, Civil and Environmental Engineering, and Biomedical Engineering are in Perkins Hall; Electrical and Computer Engineering are in Ferris Hall; Industrial Engineering and the Interdisciplinary Engineering Research Centers are in East Stadium Hall; Nuclear Engineering is in the Pasqua Engineering Building; Mechanical and Aerospace, Chemical, and Materials Science are in Dougherty Hall. The Engineering Fundamentals Division is located in Estabrook Hall. The Co-op Office and the Engineering Diversity Programs Office are in Perkins Hall. The Engineering Physics program is administered through the UT Physics Department in the Nielsen Physics Building.

**COOPERATIVE ENGINEERING AND PROFESSIONAL PRACTICE**

The five-year Cooperative Engineering Program (Co-op) is offered in order to provide an augmented engineering education that includes significant experience in industry as well as superior academic preparation. Our Cooperative Engineering Program was established in 1926. The University of Tennessee was one of the early pioneers in this valuable type of education.

Co-op work assignments differ from part-time or summer employment in that they involve regularly scheduled cycles of full-time academic terms alternating with full-time work periods, resulting in planned, career-related work terms of progressive complexity and responsibility. In introducing the student to engineering employment, the college and industry join together to offer a broader and richer preparation for postgraduate employment than can be provided by a conventional academic program. This experience in an industrial and professional environment contributes to the student’s maturity, accelerates professionalism, offers an opportunity to apply engineering course work in a real-world setting, and enables the student to define more clearly educational and career interests and objectives. All positions are paid positions, and most students are able to offset a substantial amount of their college expenses with Co-op savings.

Introduction to the Cooperative Engineering Program (for new students, transfers, second-degree students, and re-entry students) begins in the first semester at the university. Assignments are determined by employer and student. All engineering students are encouraged to visit the program office.

Candidates must be able to project a minimum of 52 weeks of Co-op experience prior to the senior year, within the regular alternating sequence, to qualify for an assignment.
Further details may be obtained from the Cooperative Engineering Program, 310 Perkins Hall, The University of Tennessee, Knoxville, TN 37996-2012. You may also contact the Co-op office via e-mail at coop@engr.utk.edu or via the program homepage at http://www.engr.utk.edu/~coop/

INTERNATIONAL ENGINEERING PROGRAM

The United States, like most countries throughout the world, can no longer thrive economically and politically if it’s market for its goods and services. To compete in the global marketplace, engineers must understand how to design and manufacture products for world-wide use. The College of Engineering works with several organizations, both on and off campus, to enable interested students to participate in significant engineering experiences abroad. Students interested in making an international experience part of their engineering education should begin exploring opportunities and develop plans during the freshman year. Language preparation to a level of substantial proficiency may be required. Thus, language preparation should be started immediately. For further information on international engineering educational programs, contact the UT Center for International Education, 1620 Melrose Avenue.

GRADUATE PROGRAM

Graduate programs leading to the degree of Master of Science are offered in eleven areas of study: aerospace engineering, chemical engineering, civil engineering, electrical engineering, engineering science, environmental engineering, industrial engineering, materials science and engineering, mechanical engineering, nuclear engineering, and polymer engineering. The degree of Doctor of Philosophy is offered in nine major subjects: aerospace engineering, chemical engineering, civil engineering, electrical engineering, engineering science, materials science and engineering, mechanical engineering, nuclear engineering, and polymer engineering. Information concerning graduate programs is given in the Graduate Catalog.

TAU BETA PI NATIONAL HEADQUARTERS

The college is honored to have the national headquarters of Tau Beta Pi, the National Engineering Honor Society, housed on our campus. This honor was earned in part through the untiring efforts of R.C. “Red” Matthews, who served as secretary-treasurer for the organization from 1905 to 1947. The suite of offices, located on Dougherty Hall, is occupied by Mr. J.D. Froula, secretary-treasurer, Roger Hawks, Assistant Secretary-Treasurer, and his staff.

CURRICULA IN ENGINEERING

National Accreditation

Since 1936, engineering programs at institutions of higher learning have been accredited by an organization formed by many engineering societies and known as the Accreditation Board for Engineering and Technology (ABET). ABET accreditation ensures that graduates of UT engineering programs are adequately prepared to enter and continue the practice of engineering. Accredited engineering programs at UT include aerospace, biosystems, chemical, civil, electrical, engineering science, industrial, mechanical, materials science, and nuclear. Co-op programs in the above areas are also accredited.

Accreditation criteria require each engineering degree program to design a curriculum and educational process that will achieve defined educational objectives consistent with ABET criteria and the mission of UT. The educational objectives of each degree program are presented by the department responsible for the program later in this chapter. In each case the objectives are consistent with the mission of the College of Engineering. That mission is to:
1. Provide high quality education in the major engineering disciplines from the undergraduate through doctoral levels through a creative balance of academic, professional, and extracurricular programs;
2. Foster and maintain mutually beneficial partnerships within UT, with alumni, friends, industry, and local, state, and federal governments through public services, assistance, and collaborative research; and
3. To be a major contributor to our nation’s technology base through scholarship and research.

In addition, the educational objectives of each degree program are also guided and consistent with the strategic objectives of the College of Engineering. Two particularly relevant strategic objectives are “to continuously improve the quality of courses, programs, and extracurricular activities, assistance, and support that enhances each student’s desire to learn and that excites each student’s interest in engineering and the work environment” and “to continuously provide and improve the education and working abilities that employers want our engineering graduates to have.”

ABET accreditation criteria also require an assessment process to ensure that program outcomes critical to successful engineering practice are being achieved. Assessment of eleven program outcomes common to all engineering disciplines required by ABET. Specifically, each engineering degree program must demonstrate that its graduates have:
1. An ability to apply knowledge of mathematics, science, and engineering;
2. An ability to design and conduct experiments, as well as to analyze and interpret data;
3. An ability to design a system, component, or process to meet desired needs;
4. An ability to function on multi-disciplinary teams;
5. An ability to identify, formulate, and solve engineering problems;
6. An understanding of professional and ethical responsibility;
7. An ability to communicate effectively;
8. The broad education necessary to understand the impact of engineering solutions in a global/societal context;
9. A recognition of the need for and an ability to engage in life-long learning;
10. A knowledge of contemporary issues;
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The College of Engineering has embraced these program outcomes as valid and valuable indicators of educational program effectiveness. Thus, the College prepares students to demonstrate sufficiency and to strive for excellence in each of these areas. This goal is achieved by ensuring that instruction and other learning experiences are provided that will produce each program outcome. Engineering courses, mathematics and natural science courses, and the humanities and social sciences each provide essential contributions to the achievement of this goal. Program outcomes that are critically dependent on humanities and social science courses are discussed in the General Education Requirements section to follow. Additional program outcomes selected by individual degree programs to supplement ABET outcomes are also discussed in subsequent sections.

DESIGNATION OF A MINOR

An engineering undergraduate may declare a minor in a non-engineering subject area and have the minor listed on the permanent record under the following conditions:
1. Minors must be officially approved and described in the UT catalog. No unofficial minors will be recognized. Minors exist in aerospace engineering, environmental engineering, materials science and engineering, engineering communication and performance, architecture, business administration, and in numerous departments in agricultural science and natural resources and arts and sciences.
2. Courses taken to satisfy the minor may also be used to satisfy engineering degree requirements, provided that the courses would be a part of engineering degree requirements even if no minor was declared. Completion of a minor often involves the taking of courses which cannot be used to satisfy the minimum requirement for an engineering degree.
3. A student should notify his or her advisor and major department office when beginning work on a minor. The intention to complete a minor must be declared at the time of application for a degree if the minor is to appear on the final transcript. Degree applications are handled by the UT Records Office.

COURSE LOAD

The maximum number of hours which can be taken by an undergraduate engineering student without special permission is 19. The Associate Dean for Academic Affairs must give permission to take 20 hours or more. In general, this decision is based on the student’s previous performance at UT.

GENERAL REQUIREMENTS

Students are advised to consult the University’s degree requirements as stated in the front section of this catalog as well as departmental requirements.

Freshman Placement Criteria. Placement criteria are in effect for the College of Engineering to promote the maximum opportunity for success among entering freshmen. A success prediction indicator (SPI) is calculated for all incoming students. The SPI is calculated by multiplying the High School GPA by 10 and adding the resulting product to the math component of the ACT. SAT scores can be converted to an equivalent ACT score to perform this calculation. A pre-requisite for the first engineering course, Engineering Freshman Calculus 101, is a SPI of equal to or greater than 55, with a co-requisite of Math 130 (pre-calculus) or higher.
math course. Math placement is determined by examination during orientation. Entering engineering students who do not meet the SPI prereq or qualitative performance in at least Math 130 have the following options:

- Attend the University of Tennessee summer session or another institution and complete a transferable math course equivalent to Math 130 (pre-calculus) with a grade of B or better and a transferable English course equivalent to English 101 with a grade of C or better. OR
- Enroll in our engineering transition curriculum that prepares students to begin EF 101 in their third semester.

Transfer Students

Transfer students, including internal UT transfers, must meet the minimum requirements stated below in order to be considered for admission to a major within the College.

1. Must have earned a minimum 2.30 cumulative average over these specific courses, or their equivalent: English 101, 102; Chemistry 120, 130; and Math 141, 142.
2. The overall record will be evaluated for quality and seriousness of purpose. An excessive number of withdrawals, incompletes, repeated courses, or failure may result in denial.

Any UT student desiring association with one of the departments of the College of Engineering should go to the departmental office for the desired major. An interview with the department head or his/her designee is held, with the major items of consideration being the same as for external transfer students. If association is granted, a College/Major/Advisor Change form is processed by the department to officially change the student's academic home.

Transfer Credit

Every attempt will be made to give maximum credit for courses taken elsewhere and transferred to the college. Discussions concerning the evaluation of transfer credits should be conducted with the head of the department (or designee) into which the student is to transfer, but only after receiving the evaluation of transfer credits by the Admissions Office.

Program for Second B.S. Degree

Upon approval by the Dean of Engineering and the Committee on Degrees of a program of study recommended by the major engineering department, a student who already holds a bachelor's degree may obtain a degree in engineering upon meeting all of the course requirements of the selected engineering program. In no case will the minimum requirement be less than 30 semester credits. The prevailing University regulations shall apply.

Satisfactory/No Credit Courses

Engineering majors may take half of the minimum hours required (9) of general education electives on a Satisfactory/No Credit (S/NC) grading basis. No other courses specified as part of the minimum degree requirements may utilize S/NC grading, unless a course is offered only on that grading basis. Students are encouraged to take courses of interest which are not part of the minimum degree requirements, and to fully utilize the S/NC grading option for such coursework.

Correspondence Courses

A student should check with his or her major department to see what restrictions there are, if any, on the use of correspondence course credit to meet the minimum degree requirements.

General Education Electives

Engineering practice is shaped by many non-technical considerations. Economic, safety and ethical matters have long been of concern. In recent years increasing influence has been exerted by legal, political, governmental, cultural, and international factors. Courses in the humanities and social sciences serve to meet the vital need for awareness and knowledge of these influences on the engineering profession. In addition, they support the UT general education goal to develop the basic skills, knowledge, attitudes and judgment necessary for effective citizenship, fulfilling personal interactions and an enriched personal life. Lastly, ABET accreditation requirements mandate a strong general education component as a necessary part of achieving engineering program objectives.

Humanities and social science courses contribute significantly to the educational objectives of each engineering program and the program outcomes desired of every engineering graduate. In fact, certain program outcomes are critically dependent on contributions from these courses. Thus, in the College of Engineering, humanities and social science courses do more than ensure adequate breadth in the educational experience. They also complement and support engineering courses in developing skills and providing experiences critical to the practice of engineering.

Program outcomes supported by the general education component in engineering curriculum and a cluster of courses relevant to that outcome are shown below. The first two outcomes, (1) the broad education necessary to understand the impact of engineering solutions in a global/societal context and (2) a knowledge of contemporary issues, have a fundamental relationship to humanities and social science courses. All engineering students are required to take at least one course from each of these clusters. Engineering programs may specify up to two other clusters that are required in their curriculum to ensure that each program outcome is achieved by either engineering coursework, general education electives, or a combination of the two.

General education requirements in English composition, mathematics, and natural science are fully satisfied by required courses in each engineering curriculum. Electives from the humanities and social sciences, in addition to supporting selected engineering program outcomes, must also fulfill general education requirements for these areas of study. Thus, to ensure general education compliance, engineering students must take at least two courses from the arts or humanities clusters; one course from multicultural studies or a two course foreign language sequence; and one course from the sciences cluster. Additional general education electives can be chosen from any other area to provide breadth or depth as desired by the student, but a minimum of 18 semesters hours is required.

To be accepted as valid within the context of the University’s general education requirements, each course must meet the generally accepted definitions that (1) humanities are the branches of knowledge concerned with humanit y and culture; (2) the arts include performance and/or analysis of the visual and written arts, music or theatre; and (3) social sciences are the studies of individual relationships in and to society. Subject areas in the humanities include history, English, philosophy, religion, and classics. The arts will include courses in music, art, theatre and creative writing. Subject areas in the social sciences include sociology, psychology, economics, anthropology, and political science. Acceptability is determined by course content, not by title or administrative home.

Examples of courses not acceptable in the engineering general education program include: (1) a language course in the student’s native language; (2) military science courses unless they are either on the approved list or officially equivalent to a course in the humanities or social sciences in another department; (3) courses whose basic content is science or mathematics; (4) engineering economy; and (5) professional courses in other fields—business, communications, etc.

A course not on the approved list must be approved by the student’s advisor, department head, and the associate dean (in this order), and the approval must be recorded on a departmental substitution form and submitted to the Records office. Transfer courses must be so approved, unless a suitable UT equivalent course number has been assigned as a part of the admissions process.

A student is urged to seek guidance from his or her advisor in choosing these electives, since they are an important part of the learning experience and preparation for engineering practice. Choices should be made on the basis of personal interest and value in engineering practice. Up to 9 hours in this category may be taken on an S/NC grading basis. Credit earned by Advanced Placement or courses transferred from another university as “Satisfactory” are included in the 9 hour limit. However, if more than 9 hours of general education courses have been earned by AP or transfer credit, students may apply for a waiver of the 9 hour limit.

These requirements are not intended to inhibit in any way the selection of courses to be taken by a student while attending UT. There may be courses of interest to a student which are not included on the lists below, but which would be of great value in the student’s education. Students are encouraged to consult with their advisor in order to incorporate such courses into their program of study.

The requirements for the general education component of all engineering curricula are:

5. A minimum of:
   a. two courses from the Humanities or Arts clusters;
   b. one course from the Multicultural Studies Cluster or two foreign language courses;
   c. one course from the Social Sciences Cluster.
6. Courses may simultaneously meet more than one requirement (e.g. a multicultural course may also satisfy the Engineering Practice in a Global/Societal Context Cluster). If both courses in the same language are taken, (b) the language cannot be the native language of the student.

APPROVED GENERAL EDUCATION ELECTIVES

Courses included on the list below have been approved by the faculty as general education electives. Any course not on this list must be approved through the department prior to enrollment in the course. Where such phrases as “any psychology course” are used, specific courses in that area are specifically excluded since the content is variable. Students should seek approval from their advisor prior to enrollment in such special topics courses.

Engineering Practice in a Global/Societal Context Cluster


Contemporary Issues Cluster

African and African-American Studies 343, 364, 420, 429, 442, 473, 480, 483; Agriculture and Natural Resources 101, 333; American Studies 343, 345, 418; Anthropology 130, 320; Business Law 301; Child and Family Studies 220, 240; Communications 100, 150; Geology 201, 202; History 320, 442, 446; Human Services 220; Philosophy 240, 290, 342, 344, 345, 373, 375, 382, 389; Political Science 311, 350; Political Studies 319; Sociology 110, 319, 330, 340, 343, 344, 345, 360, 363, 373, 414, 415, 442, 446, 451, 462, 464; Speech Communication 469; University Studies 311, 312, 321, 322; Women’s Studies 220, 230, 310, 360, 375.

Multi-disciplinary Teams Cluster

Counselor Education and Counseling Psychology 206, 306; Psychology 360, 409, 440; Sociology 130, 320; Speech Communication 220, 230, 240, 300, 310, 320, 330, 420.

Professional and Ethical Responsibility Cluster

Military Science 420; Philosophy 240, 342, 344, 345, 346; Religious Studies 344, 345; University Studies 322.

Effective Communications Cluster

English 263, 295, 355, 360, 455; Information Sciences 450; Journalism 450, 456; Speech Communication 210, 220; Theatre 220, 221. Any sequence of foreign language courses.

Life-Long Learning Cluster

Cultural Studies in Education 302, 451; Philosophy 110, 111; Psychology 310.

Aesthetics in Design Cluster


Humanities Cluster

Any British or American literature course. Any foreign language literature course including those using English translations. Any course from History, Philosophy, Medieval Studies or Religious Studies. Asian Languages 311, 312, 313, 314; Cinema Studies 281, 323, 325, 334, 420, 433, 465; Classics 221, 222, 253; Comparative Literature 202, 203; Women’s Studies 210, 215, 320, 383.

Arts Cluster

Architecture 111; Art 191*; Art History 172, 173, 183; Classics 232, 233; English 263, 363; Music*; Music History 110, 115, 120, 210, 220, 290, 310, 330, 340, 341, 350, 380, 390; Philosophy 350, 353; Theatre 100, 220*, 310, 311, 313.

* Courses involving skill development in the arts (Art 191, Theatre 220 or music courses that include vocal or instrumental performance) may be used as General Education Electives up to maximum of 3 semester hours.

Multicultural Studies Cluster

Any sequence of foreign language courses. Any course from African and African-American Studies, Latin American Studies. American Studies 310, 343; Anthropology 130, 313, 315, 319, 373; Asian Studies 101, 102, 332, 333; Business Administration 311; Economics 321, 323; Geography 320; Political Science 355, 365, 452, 454, 459, 463; Religious Studies 101, 102, 232, 333, 373, 374, 376, 379, 381, 383; Women’s Studies 360.

Social Sciences Cluster


AMERICAN HISTORY REQUIREMENT

Engineering students, regardless of national origin, must fulfill the American history requirement described elsewhere in this catalog. Those students who have not had the required year of American history in high school may choose the required six semester hours from History 221 and 222, or other courses deemed suitable by the Department of History. These hours may be counted as part of the required block of humanities and social science electives.

TECHNICAL ELECTIVES

Technical electives are to be selected with the advice and approval of the student’s major department. In some of the curricula tabulations a choice of such electives is indicated, and regulations in regard to their selection are stated.

THE VOLUNTARY ROTC PROGRAM

Engineering students may participate in the ROTC Program. Advanced ROTC courses (300 and 400 series) may be counted as technical elective credit toward an engineering degree up to a total of six (6) semester hours. Normally, Military Science courses cannot be used as humanities/social science electives. Individual departments determine the appropriate substitutions.

APPROVAL OF ELECTIVES AND SUBSTITUTIONS

Each student shall discuss with an advisor the status of the program of study no later than the beginning of the second semester prior to anticipated graduation. Any substitutions to or substitutions in the program, or electives requiring special approval, must be cleared in writing at that time, and it is each student’s responsibility to see that all necessary approvals are secured. Inattention to such matters will most likely delay graduation.

ENGINEERING FUNDAMENTALS DIVISION

Professors:

J.R. Parsons (Mechanical and Aerospace Engineering and Engineering Science), Director; R.M. Bennett (Civil and Environmental Engineering); J.H. Forrester (Mechanical and Aerospace Engineering and Engineering Science); O. Soliman (Mechanical and Aerospace Engineering and Engineering Science).

Associate Professors:

C.D. Pionke (Mechanical and Aerospace Engineering and Engineering Science); D. Raj Raman (Agricultural and Biosystems Engineering); T.H. Scott (Nuclear Engineering); J.E. Seat (NSF Research Associate Professor), Ph.D. Tennesse; T.H. Scott (Nuclear Engineering); F.E. Weber (Chemical Engineering); D.C. Yoder (Agricultural and Biosystems Engineering).

The Engineering Fundamentals Division is the academic home for all first year engineering students. Located in Estabrook Hall, the Division serves as a focus for all freshman student activities. The faculty of the Division act as academic advisors and teach the principal courses in Engineering Fundamentals. These courses are designed to prepare students for entry into the Sophomore year of every degree program in the College. Academic standards in the first year are necessarily high. To assist students with deficient academic backgrounds in the necessary math and computer skills, supplementary courses are offered as needed. No degree is awarded by the Engineering Fundamentals Division. The division co-administers (with the College of Education) the Engineering and Communication and Performance Minor for engineering students desiring addi-
ration training and certification in team facilitation and organizational communication.

New freshman students are assigned to the Engineering Fundamentals Division for academic advising and career counseling until they have completed the freshman curriculum. Freshman students admitted to the College of Engineering are required to designate a field of study by the end of their freshman year. As sophomores, students are assigned faculty advisors in their selected departments.

BIOSYSTEMS ENGINEERING
(See College of Agricultural Sciences and Natural Resources)

CHEMICAL ENGINEERING

Professors:
J.R. Collier (Head), Ph.D. Case Institute of Technology; M.R. Aliy (Adjunct), Ph.D. Pittsburgh; P.R. Bienkowski, Ph.D. Purdue; R.M. Counce, Ph.D. Tennessee; P.T. Cummings (Distinguished Scientist), Ph.D. U. of Melbourne (Australia); G.C. Frazier, Jr. (Emeritus), D. Eng. Johns Hopkins; J.M. Holmes (Emeritus), Ph.D. Tennessee; C.F. Moore (Distinguished Service Professor), Ph.D. Louisiana State; J.J. Perona (Emeritus), Ph.D. Northwestern, PE; J.W. Prados (University Professor), Ph.D. Tennessee; PE; J.S. Watson (Adjunct), Ph.D. Tennessee.

Associate Professors:
J.S. Arnold (Adjunct), Ph.D. Tennessee; D.D. Bruns, Ph.D. Houston; J.P. Coates (Adjunct), Ph.D. University of West London; B.H. Davidson (Adjunct), Ph.D. California Institute of Technology; C.S. Daw (Adjunct), Ph.D. Tennessee; D.W. DePaoli (Adjunct), Ph.D. Idaho; J.J. Ferrada (Adjunct), Ph.D. Tennessee; M.C. Hu (Adjunct), Ph.D. Idaho; J.W. Lee (Adjunct), Ph.D. Cornell; J.J. Sirola (Adjunct), Ph.D. Wisconsin; T.W. Wang, Ph.D. Massachusetts Institute of Technology; F.E. Weber, Ph.D. Minnesota.

Assistant Professors:
B.J. Edwards, Ph.D. Delaware; P.D. Frymier, Ph.D. Virginia; D.J. Keffler, Ph.D. Minnesota.

BACHELOR OF SCIENCE PROGRAM

Chemical engineering deals with the development, design, operation, and management of plants and processes for economical, safe conversion of chemical raw materials to useful products. It is a broadly based discipline with heavy emphasis on chemistry and mathematics, with supporting study in areas such as physics, materials, and humanities.

Chemical engineering graduates of the University of Tennessee possess the knowledge base, intellectual skills, and professional commitment that prepare them for innovative technical leadership, graduate study, productive service to society, and continued professional growth through lifelong learning. Preparation is based in the learning objectives identified below, regular evaluation of the achievement of these objectives, and use of evaluation results to improve the educational process.

Technical Knowledge Base: Graduates of the UT chemical engineering program demonstrate the ability to apply knowledge of mathematics, chemistry, other sciences, and engineering to identify and solve problems dealing with material and energy balances applied to chemical processes; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transfer; continuous and stagewise separation operations; chemical kinetics and reactors; and process dynamics and control.

Analytical Skills: Graduates of the UT chemical engineering program demonstrate the ability to apply the following analytical skills in the solution of engineering problems: differential and integral calculus, ordinary differential equations, linear algebra, statistical methods, and numerical methods.

Problem Formulation and Solution Skills: Graduates of the UT chemical engineering program demonstrate the ability to formulate a technical problem in terms that permit a solution, identify the appropriate tools to address a technical problem, make simplifying assumptions required to solve with an appropriate level of rigor, identify and collect information needed to obtain the solution, and evaluate the reasonableness of the solution.

Experimental Skills: Graduates of the UT chemical engineering program demonstrate the ability to plan experiments to meet specified objectives, conduct such experiments carefully and safely, and analyze and interpret experimental data in terms of process models.

Information Technology Skills: Graduates of the UT chemical engineering program demonstrate the ability to apply computer skills in engineering problem solving. These include computation, communication, and data acquisition skills that keep pace with evolving technology.

Process Design and Synthesis Skills: Graduates of the UT chemical engineering program demonstrate the ability to formulate and solve open-ended problems that require evaluation of alternatives with respect to specified criteria; size equipment to meet process objectives; apply the principles of engineering economics to estimate capital investment and operating costs for specified process equipment and systems; develop an appropriate flowsheet to meet a process objective; calculate the material and energy balances for a given process flowsheet; employ computer-based process design tools and techniques; optimize the design of a conceptual process with respect to specified criteria that include safety, environmental impact, operability, and economics; and analyze and compare alternative designs.

Communication Skills: Graduates of the UT chemical engineering program demonstrate the ability to communicate effectively in writing, speaking, and listening in a variety of contexts. Specific skills include the ability to write effective reports, experimental procedures, memorandum, and similar documents; make effective oral presentations and critique presentations by others; prepare and use appropriate visual representations in both written and oral presentations; and critically evaluate technical material presented in lectures and seminars.

Teamwork Skills: Graduates of the UT chemical engineering program demonstrate the ability to function as effective team members and leaders. This includes the ability to work effectively with other team members; employ appropriate team facilitation procedures as needed; organize and lead a team effort; and contribute individual expertise in achieving team goals.

Lifelong Learning Skills: Graduates of the UT chemical engineering program recognize the need for and are able to engage in lifelong learning. Students will have the ability to obtain needed information from libraries and electronic data bases; the ability to use the Internet as an effective communication and research tool; the ability to use distance learning media to independently complete required assignments; and familiarity with lifelong learning resources available through professional societies.

Professional Commitment: Graduates of the UT chemical engineering program demonstrate high standards of professional and ethical responsibility. Students are required to take a course preparing them for the Fundamentals of Engineering examination, receiving a grade based on their performance on a “mock Fundamentals of Engineering examination,” and are strongly encouraged to pursue the path to registration as Professional Engineers.

Safety, Health, and Environmental Protection: Graduates of the UT chemical engineering program demonstrate an understanding of chemical process safety, including occupational safety and health and minimization of adverse environmental impact.

Understanding the Global and Societal Impact of Engineering: Graduates of the UT chemical engineering program demonstrate an appreciation for the global and societal impact of engineering decisions.

Appreciation of the Cultural Heritage: Graduates of the UT chemical engineering program demonstrate an appreciation for human cultural heritage.

The curriculum provides a central core of required courses with flexibility in the upper-division years to permit emphasis on preparation for graduate school or professional employment.

DEPARTMENTAL GRADUATION REQUIREMENTS

To graduate in chemical engineering, students must complete the published curriculum with a grade of C or better in all required chemical engineering courses. A minimum of 18 semester hours of general education courses are required. These courses must meet the college general education requirements listed under “Curricula in Engineering.” A 3 semester-hour technical writing course must be included in the general education electives.

HONORS PROGRAM

The honors program encourages highly motivated students to experience a more rigorous preparation in chemical engineering. Admission is selective. Application to the honors program is made when the student applies for upper division status. Honors requirements are: credit for 3 of the 4 honors seminars (CHE 307, 308, 407 and 408), CHE 447, one of CHE 467, 477, 488 or 498 as a technical elective and Chem 483 as a chem option. Students interested in the honors program should consult the department’s honors coordinator.
PROGRESSION TO UPPER DIVISION

Progression of chemical engineering students to departmental upper division courses is competitive and is based on capacity. Factors considered include overall grade point average, performance in selected lower division courses and evidence of satisfactory and orderly progress through the prescribed curriculum.

Upper-Division Status: A lower-division student may apply for progression to Upper-Division Status after completing CE 200, 230, 240 and 250 with a grade of C or better in each course and an overall GPA of 2.5 or better.

Provisional Status: Students who have completed CE 200, 230, 240, and 250 with an overall GPA of at least 2.1 may apply for provisional status. The granting of Provisional Upper-Division Status is based on the availability of space in the departmental programs after Upper-Division Status students have been accommodated. Provisional students are required to demonstrate the ability to perform satisfactorily in upper division courses by completing a total of seven departmental courses with a grade of C or better in each course (including the four required for Upper-Division Status). Permission to continue with upper-division classes depends on this minimum level of performance.

Any student with an overall GPA below 2.1 will not be admitted to upper division Chemical Engineering courses. Students who have not been admitted to Upper-Division or Provisional Status will be dropped from upper-division departmental class rolls.

Transfer students at the upper-division level are admitted on a Provisional Status basis only.

GRADUATE STUDY PROGRAM

Graduate programs leading to the degrees of Master of Science and Doctor of Philosophy in Chemical Engineering are offered. The University’s Graduate School operates a Resident Graduate Program at Oak Ridge and Kingsport. See the Graduate Catalog for detailed information.

CIVIL AND ENVIRONMENTAL ENGINEERING

Professors:
- G.D. Reed (Condra Professor and Head), Ph.D., P.E. (Arkansas); R.M. Bennett, Ph.D., P.E., Illinois; E.G. Burdette (Fred N. Peebles Professor), Ph.D., P.E., Illinois; A. Chatterjee, Ph.D., P.E., North Carolina State; W.T. Davis, Ph.D., Tennessee; J.H. Deatherage, Ph.D., P.E., Tennessee; E.C. Drumm, Ph.D., P.E., Arizona; D.W. Goodpasture, Ph.D., P.E., Illinois; W.L. Grecco (Emeritus), Ph.D.
- Michigan State; K.W. Heathington (Emeritus), Ph.D., Northwestern; J.B. Humphreys, Ph.D., Texas A&M; W.A. Miller (Emeritus), Ph.D., P.E., Georgia Institute of Technology; R.B. Robinson (Fisher Professor), Ph.D., P.E., Iowa State; J.L. Smoot, Ph.D., P.E., VPI; B.A. Tschantz (Condra Professor), ScD., P.E., New Mexico State; C.R. Walker (Emeritus) M.S. Massachusetts Institute of Technology; J. Wegmann, Ph.D., Northwestern.

Associate Professors:
- K.C. Chou, Ph.D. Northwestern; C.D. Cox, Ph.D. Penn State; L.D. Han, Ph.D. California (Berkeley); M. Mauldon, Ph.D, California (Berkeley); T.L. Miller, Ph.D., Tennessee; S.H. Richards, Ph.D., P.E., Tennessee; K.G. Robinson, Ph.D. VPI; R.F. Tiry (Emeritus), B.S. Marquette

Assistant Professor:
- M. Jackson, Ph.D., P.E., Oregon State.

Environmental Engineering courses in which a D is the highest grade earned may be counted toward graduation.

ELECTIVES

Electives are chosen to meet student career objectives and program accreditation requirements. Students must consult with their advisor and have their selections pre-approved. A student must have a GPA of 2.75 or higher or approval of the instructor to take 500-level courses for undergraduate credit.

ENVIRONMENTAL ENGINEERING MINOR

The College of Engineering offers a minor in Environmental Engineering to those undergraduate students whose academic history provides the prerequisites for the courses required by the minor. The minor requires the completion of a minimum of 21 credits in course work which builds the foundation of an environmental engineering perspective. Some of the courses used in the minor may also satisfy a requirement for a major. Students are advised that the first professional degree in Environmental Engineering at the University of Tennessee is the M.S. in Environmental Engineering which builds on the minor.

COURSE REQUIREMENTS

Choose One:
- CHEM 230 Inorganic Chemistry
- CHEM 310 Analytical Chemistry
- CHEM 350 Organic Chemistry

Required:
- MCR 210 General Microbiology

Choose Two:
- CHE 200 Chemical Engineering Fundamentals
- BS 243 Material and Energy Flow in Bio Systems
- CE 380 Water & Wastewater Treatment
- CE 395 Hydrology or BS 315 Soil and Water Conservation

Choose One:
- GEO 202 Earth as an Ecosystem
- PHIL 346 Environmental Ethics

Required:
- CE 486 Air and Waste Management

Students are asked to file their intent to complete the Minor with the office of the Department of Civil and Environmental Engineering, 223 Perkins Hall. The student’s home department advisor will then be supplied with the information about the Minor requirements to assist with prerequisite sequencing. A copy will be filed with undergraduate records so the Minor, once completed, will be shown on the student’s transcript.

MASTER OF SCIENCE PROGRAM

Graduate programs in Civil Engineering and Environmental Engineering leading to the degrees of Master of Science are offered to graduates of recognized undergraduate curricula. The general requirements for the masters’ degrees are stated in the Graduate Catalog.
DOCTORAL PROGRAM

Graduate work leading to the degree of Doctor of Philosophy with a major in Civil Engineering is offered. Major fields of study include environmental engineering, geotechnical materials, structural engineering, transportation, and water resources.

The general requirements for the doctoral degree are stated in the Graduate Catalog.

ELECTRICAL AND COMPUTER ENGINEERING

Professors:
M.O. Pace (Acting Head), Ph.D. Georgia Institute of Technology; M. Abidi (Weston Fulton Professor), Ph.D. Tennessee; J.D. Birdwell, Ph.D. Massachusetts Institute of Technology; B.K. Bose (Condra Chair of Excellence), Ph.D. Calcutta; D.W. Bouldin, Ph.D. Vanderbilt, P.E.; J.S. Lawler, Ph.D. Michigan State; A. Pujol (UTSI), Ph.D. Tennessee; J.R. Roth (Weston Fulton Professor), Ph.D. Cornell.

Emeritus Professors:

Associate Professors:
C.T. Abdallah, Ph.D. Georgia Institute of Technology; B.W. Bomer (UTSI), Ph.D. Tennessee; P.B. Crilly, Ph.D. New Mexico State; S.K. Islam, Ph.D. Connnecticut; R.D. Joseph (UTSI), Ph.D. Case Institute of Technology; D.B. Koch, Ph.D. Missouri-Rolla; D.F. Newport, Ph.D. Tennessee, P.E.; A. Walker, Ph.D. North Carolina State.

Emeritus Associate Professors:

Assistant Professors:

BACHELOR OF SCIENCE PROGRAMS

GOALS

The goals of the B.S. degree programs in electrical and computer engineering are to: (a) prepare students for entry into the profession; (b) instill in students the capabilities required by the discipline, the recognition of the need to enhance the discipline, and the desire for lifelong learning; and (c) equip students with a general knowledge of technical and non-technical disciplines so that they are prepared for further study in other fields including professional and graduate education.

The B.S. degree programs are based on a series of integrated courses. Students advance through the program in a sequential manner guided by prerequisite and co-requisite courses in the showcase curriculum. This integrated sequentially developed program is highlighted by the systematic inclusion of the design process introduced in the sophomore year.

PROGRAM EDUCATIONAL OBJECTIVES

The program educational objectives of the Electrical and Computer Engineering programs include: (1) an understanding of the engineering sciences necessary to analyze and design complex devices and systems containing hardware and software components; (2) an understanding of the basic sciences including chemistry and physics; (3) an understanding of the engineer's role in society; (4) an understanding of the engineering sciences necessary to analyze and design complex devices and systems containing hardware and software components; (5) an understanding of the engineering sciences necessary to analyze and design complex devices and systems containing hardware and software components; (6) a progression of design projects and tasks throughout the program; (7) an orderly student progression through the program; and (8) achievement of all eleven Program Outcomes common to all engineering disciplines and the two additional department specified outcomes. See Program Outcomes below.

PROGRAM OUTCOMES

In addition to the eleven program-outcomes listed in the College of Engineering section on National Accreditation (listed on page 104), electrical and computer engineering program outcomes also include (a) experience in using organizational skills in team management and negotiation; and (b) ability to use creative and technical skills in analytical problem solving in the discipline and other engineering related fields. Both Electrical and Computer Engineering programs are under continuous assessment and improvement based on Engineering Criteria 2000. The Advisory Committee to the department, which is made up of persons from industry, government, higher education, students and recent graduates, and faculty, provides constituent input for setting program educational objectives and outcomes and establishing the requisite assessment modes for the program.

GENERAL

The courses of study for the B.S. degree in Electrical Engineering and B.S. degree in Computer Engineering are designed to provide a foundation in both the basic sciences and the specialized areas of their respective discipline. The programs also have sufficient general education electives to enhance the cultural growth of the student and develop professionals with a strong social awareness. The faculty seeks to keep classes small enough to allow effective interaction with students.

The selection of general education elective courses is left to each student but must be made in accordance with established College of Engineering Policy. Students are required to satisfy the following cluster distribution requirements: Engineering in a Global/Societal Context cluster (1 course), Con-
GRADUATE STUDY PROGRAM

Comprehensive course and research programs for the degrees of Master of Science and Doctor of Philosophy in electrical engineering are offered for students with career goals such as advanced design, research, and teaching. Students admitted to the graduate program are expected to have a minimum grade point average of 3.0 for all undergraduate study, and for the senior year. Students with a B.S. or B.A. degree in a field other than Electrical Engineering are required to take certain ECE undergraduate courses before beginning the graduate program. See the Graduate Catalog for complete details on the graduate program.

The ECE Department has a long-standing tradition of research excellence in analog and mixed-signal signal integrated circuits, computer vision, image processing, information processing, industrial, plasma engineering, power electronics, and sensors. Various government agencies, laboratories, and industrial partners support research of the ECE faculty at a level of approximately $3.5M per year. The campus is located within the vicinity of the Oak Ridge National Laboratory (ORNL). The ECE Department sustains a strong link with ORNL in their efforts at advancing the nation’s energy resources, scientific knowledge, educational foundations, and economic competitiveness.

ENGINEERING PHYSICS

Lee L. Riedinger (Head)  
Stuart B. Elston, Coordinator

Engineering physicists typically work in areas of applied science and emerging technology in which standard engineering practices are rapidly evolving to keep pace with advances in science; they are often involved in developing new engineering methods and principles. The goal of the Engineering Physics B. S. program is to prepare students to apply the principles and problem-solving approaches of physics to the solution of engineering problems at the frontiers between science and technology, by:
1. providing students with a thorough knowledge of mathematics, science, and engineering science with an emphasis on the principles of physics and of the derived physical, chemical, and biological sciences as appropriate to individual career goals;
2. training students in the communication, team cooperation, and problem identification and solving skills needed to practice engineering art in the modern world;
3. preparing students through example and experience to apply those principles and skills to the design and conduct of experiments, to the analysis and interpretation of measured results, and to the design of components, processes, and systems that meet specific, identified needs; and
4. instilling in students understanding and appreciation of the cultural, historical, societal, economic, and environmental contexts in which problems of engineering and science arise, and to promote commitment to seek solutions which achieve appropriate balance of cultural, social, and technical values.

The program in Engineering Physics is designed to fulfill the educational requirements for professional work in various fields of applied science which are based upon a thorough knowledge of physics. The first two years of the curriculum are concerned with fundamental courses in engineering, science, mathematics, and general education. In the upper division, the curriculum allows some choice of courses in engineering and in physics depending on the interest and career goals of the student. The undergraduate program is a complete, professional program, equipping the student for entry into a variety of work in industry and research. The program also leads to graduate work in either physics or engineering.

ENVIRONMENTAL ENGINEERING  
(See Civil Engineering)

INDUSTRIAL ENGINEERING

Professors:
A.B. Badrin (Head), Ph.D. Central Florida, P.E.;  
W.W. Claycombe (Emeritus), Ph.D. Virginia Polytechnic Institute, P.E.;  
G.W. Garrison (UTSI), Ph.D. North Carolina State;  
H.L. Loveless (Emeritus), M.S. North Carolina State, P.E.;  
J.A. Bontadelli (Emeritus), Ph.D. Ohio State, P.E.

Associate Professors:

Assistant Professors:

The undergraduate curriculum in industrial engineering provides a strong background in both fundamental engineering principles and the analytic methods necessary for solving the multi-faceted problems associated with the production, maintenance, and delivery of goods and services. In particular, this curriculum emphasizes the knowledge and skills necessary to design integrated systems of people, materials, equipment, and energy wherever they are found, such that the overall system functions at an optimal level and such that the needs of the human components of the system are adequately met.

GOALS

The goals of the Industrial Engineering undergraduate program are to prepare students to contribute to the profession of Industrial Engineering and to prepare them for further study, including professional and graduate education.

OBJECTIVES

The objectives of the Industrial Engineering Program include enabling the students to obtain:
(a) An understanding of fundamental engineering principles, mathematics, science, and statistics.
(b) An understanding of and an ability to apply the following concepts to the multi-faceted problems associated with the production, maintenance, and delivery of goods and services: fundamental human factors which influence engineering design, the economic analysis of alternative design choices, introductory economics and accounting, quality control techniques, manufacturing processes and materials, production and inventory systems design and control, the mathematical modeling and simulation of complex systems, and the design and installation of information acquisition and control systems.
(c) An ability to communicate effectively, both orally and in writing, to function on multidisciplinary teams, to have a knowledge of pertinent contemporary issues, and to recognize the need for a commitment to life-long learning.

This curriculum emphasizes the knowledge and skills necessary to design integrated systems of people, materials, equipment, and energy, such that the overall systems functions at an optimal level and such that the needs of human components of the system are met. The solid, broad base in engineering, combined with education in applying engineering methodology to traditionally non-engineering problem areas as provided through the Industrial Engineering curriculum, leads to participation by Industrial Engineers in an unlimited range of fields; including, among others, retail distribution, banking, health care delivery, corporate management, municipal management, food industry, as well as traditional areas of manufacturing.

OUTCOMES

The eleven program outcomes listed in the College of Engineering section on National Accreditation are the accepted outcomes of the Industrial Engineering Department.

UNIVERSITY OF TENNESSEE GENERAL EDUCATION REQUIREMENTS

Industrial Engineering students are required to take Economics 201 and two English electives. They must select the remainder of their humanities/social science elective courses to satisfy the University of Tennessee General Education Requirements in accordance with the established College of Engineering Policy. An Industrial Engineering advisor will assist the student in selecting courses to meet these requirements.

GRADUATE STUDY PROGRAMS

The Department of Industrial Engineering offers a graduate program leading to the Master of Science degree with a major in Industrial Engineering, concentrations in traditional industrial engineering, engineering management, manufacturing systems engineering, and product development and manufacturing. The Ph.D. with a major in Engineering Science is available through the Department of Engineering Science and Mechanics with a specialization in Industrial Engineering.

Students who enroll in the Master of Science degree may select a concentration in either Industrial Engineering, Engineering Management, or Manufacturing Systems Engineering. In manufacturing, a dual degree program leading to an MBA and MSIE is available. Admission is open to graduates of ABET—accredited undergraduate curricula in engineering, or to graduates of other technical curricula who satisfy prerequisites depending
on their academic backgrounds and industrial experiences. Policies concerning prerequisite requirements will be determined by the Industrial Engineering faculty.

NOTE: Any 400-level course required in the Bachelor of Science in Industrial Engineering program at UT may not be used for graduate credit in the M.S. degree program.

INDUSTRIAL ENGINEERING AND MANUFACTURING SYSTEMS ENGINEERING

Under the Industrial Engineering and Manufacturing Systems Engineering Concentration, students may select either the thesis or non-thesis option. The thesis option requires 24 hours of coursework and 6 hours thesis. The non-thesis option requires 30 hours of course work plus a 3-hour industrial design project.

Depending upon a student’s background and career objectives, graduate work in Industrial Engineering enables the student to select an area of specialization from operations research, human factors engineering, quality engineering, manufacturing and reliability engineering, or general industrial engineering. In addition to the concentration in manufacturing systems engineering, a dual degree program, requiring a total of 67 semester hours of coursework, is available in manufacturing, and leads to an MBA and an MS degree.

It is also possible in either concentration for a student to select minors in engineering, mathematics, psychology, business, computer science, statistics, or economics.

ENGINEERING MANAGEMENT

The Engineering Management Concentration has an additional admission requirement of two years’ industrial experience as a practicing engineer or scientist, or current full-time employment in an appropriate engineering or applied science position. The program is non-thesis and requires 33 hours of coursework plus a 3-hour capstone project.

BACHELOR OF SCIENCE PROGRAM

Materials Science and Engineering is concerned with the science and technology needed to develop and apply materials for the benefit of society. The undergraduate program is designed to prepare students to undertake materials science and engineering careers or to enter graduate programs in this or related disciplines. In order to accomplish this overall goal, the specific educational objectives of the program for the degree of B.S. in Materials Science and Engineering are:

1. To provide students with a knowledge of the fundamentals of appropriate physical and chemical sciences, mathematics, and engineering sciences, and to demonstrate the applications of these principles to solve engineering problems with an emphasis on the materials processing, structure, properties, and performance. This knowledge base includes the development of analytical and experimental skills.

2. To provide students with experiences in design and materials selection such that they can design components, systems, or processes with consideration of economic, safety, environmental, and social issues.

3. To develop professional skills in such areas as written and oral communication, problem-solving, and working in diverse teams that prepare graduates to practice materials engineering in contemporary and global environments.

4. To provide students with a general education component that complements the technical content, for the appreciation of cultural and social values, for understanding the impact of engineering solutions on society, and for personal development.

The field of Materials Science and Engineering is quite broad, encompassing metallic, ceramic, and polymeric materials, as well as composites made from combinations of materials. Consequently, the curriculum contains a central core of courses that are applicable to all materials types with flexibility in the upper division years to permit concentration and in-depth coverage of specific materials categories. By judicious choice of electives the student may get a broad perspective or may develop a specialty area.

A minimum of 18 semester-hours of general education courses are required by all engineering degree programs in order to meet the UT general education goals, as discussed above. The major in Materials Science and Engineering specifically requires that Economics 201 and one course from the Effective Communication Cluster be included as a part of this group.

Graduation in materials science and engineering requires a minimum grade point average of 2.00 for all departmental courses.

PROGRESSION TO UPPER-DIVISION PROGRAMS

Progression of students to departmental Upper-Division courses is competitive. Factors considered include overall grade point average, performance in selected lower-division courses and evidence of satisfactory and orderly progress through the prescribed curriculum.

Upper-Division Status

A Lower-Division student formally applies for Upper-Division Status after completing 50 semester hours of Lower-Division engineering curriculum course work with an overall GPA of at least 2.4. This must include Materials Science and Engineering 201.

Provisional Status

Students who have completed 50 semester hours of Lower-Division engineering curriculum course work with an overall GPA between 2.0 and 2.4 may apply for provisional status. The granting of Provisional Upper-Division Status is based on the availability of space in the departmental programs after Upper-Division Status students have been accommodated. Provisional students are required to demonstrate their ability to perform satisfactorily in upper-division courses by attaining a minimum GPA of 2.0 in at least 8 hours of 300-level required courses specified by the department. Further progression to upper-division courses is dependent upon this minimum level of performance.

Transfer Students

At the Upper-Division level students are admitted on a Provisional Status basis only. Any student presenting more than 28 hours of Lower-Division engineering curriculum course work by transfer credit is considered to be a transfer student.

MINOR IN MATERIALS SCIENCE AND ENGINEERING

A minor in Materials Science and Engineering (MSE) is offered through the College of Engineering to those undergraduate students who have met the prerequisites for the courses required by the minor. The minor requires completion of a minimum of 18 semester hours in course work which develops a foundation in MSE and allows concentration in MSE areas to be selected by the students (e.g., metallurgy, polymers, ceramics, composites, or electronic materials). Some of the courses used for the MSE minor may also satisfy requirements for the student’s major.

Students may enroll in the minor program by completing a form at the office of the Department of Materials Science and Engineering, 434 Dougherty Engineering Building. A copy of the completed enrollment form and information on the minor requirements will be forwarded to the student’s home department advisor. A copy of the form also will be filed with the Office of Records and Certification so that, upon completion, the minor will be shown on the student’s transcript.

COURSE REQUIREMENTS

Required courses:
Materials Science and Engineering 201 and 380.

Choose at least one:
Materials Science and Engineering 410, 402, 340, 360, and 472.

Choose at least three, at least one of which must be at the 400 level:
Any of the Materials Science and Engineering 300-400 courses;
Civil and Environmental Engineering 321 and 421;
Chemical Engineering 330 and 447;
Industrial Engineering 330;
Mechanical Engineering 336 and 466;
Engineering Science 321, 322, 323, 423, 426, and 473;

MATERIALS SCIENCE AND ENGINEERING

Professors:
Patrick R. Taylor (Head), Ph.D. Colorado School of Mines, P.E.; R.S. Benson, Ph.D. Florida State; C.R. Brooks (Emeritus), Ph.D. Tennesse; Raymond A. Buchanan, Ph.D. Vanderbilt, P.E.; Edward S. Clark (Emeritus), Ph.D. California; N.B. Dahote (UTSI), Ph.D. Michigan State; J.F. Fellers, Ph.D. Akron; Marion G. Hansen, Ph.D. Wisconsin; P.K. Liaw (Rachell Chair of Excellence), Ph.D. Northwestern; Douglas H. Lowndes, Ph.D. Colorado; Carl D. Lundin, Ph.D. Rensselaer; Carl J. Maghre, Ph.D. Kentucky; Ben F. Oliver (Emeritus), Ph.D. Penn State; A.J. Pedraza, Ph.D. LaPlata (Argentina); George M. Pharr, Ph.D. Stanford, P.E.; Paul J. Phillips, Ph.D. Liverpool (UK); Joseph E. Spriuill, Ph.D. Tennesse; E.E. Stansbury (Emeritus), Ph.D. Cincinnati.

Associate Professors:
William T. Becker, Ph.D. Illinois; Thomas T. Meek, Ph.D. Ohio State.

Assistant Professor:
Kevin Kit, Ph.D. Delaware.
MECHANICAL AND AEROSPACE ENGINEERING AND ENGINEERING SCIENCE

Professors:

Professors (Emeritus):

Associate Professors:
J.A. M. Boulet, Ph.D. Stanford; J.S. Freeman, Ph.D. Wisconsin; W.R. Hamel, Ph.D. Tennessee; G.S. Iannelli, Ph.D. Tennessee; M. Karsa, Ph.D. Ecole Polytechnique (Canada); G. Kawiecki, Ph.D. West Virginia; J.E. Lyné, M.D., Ph.D. North Carolina State; M.S. Madhukar, Ph.D. Drexel, K. Nguyen, Ph.D. Colorado; C.D. Pionke, Ph.D Georgia Tech, P.E.; N. Yu, Ph.D. California (San Diego).

Associate Professor (Emeritus):
S.E. Becker, Ph.D. North Carolina State, P.E.

Assistant Professors:
R.L. Kress, Ph.D. Arizona, P.E.; M. Zheng, Ph.D. University of Calgary (Canada).

GENERAL

The department offers a B.S. in Mechanical Engineering, Aerospace Engineering, and Biomedical Engineering. At the graduate level the M.S. and Ph.D. degrees are offered in Mechanical Engineering, Aerospace Engineering, and Engineering Science. The mission of the department is to provide a broad base integration of courses and experiences that prepare graduates to practice their profession successfully, to apply their skills to solve current engineering problems collaboratively, and to help advance the knowledge and engineering practice in their fields. Further information can be found on the department’s web site: http://www.engr.utk.edu/maes/

BACHELOR OF SCIENCE PROGRAMS

Mechanical Engineering has two main stems. (1) thermos/fluids science and (2) machine science. Historically, both are derived from the sciences associated with the generation of mechanical power and the transmission of this power through various machine elements. Today, fundamental concepts are applied to various power units such as steam turbines, gas turbines, and internal combustion engines.

Mechanical Engineering is a versatile and broadly based engineering discipline. The foundation is in the basic sciences and requires an understanding of such subject areas as solid and fluid mechanics, thermodynamics, heat transfer, structures, vibrations, mechanical design, manufacturing processes, and instrumentation. Design projects throughout the program develop student skills in handling open-ended problems. Because of the broad scientific foundation and design training in this program, graduates are found in nearly every industry and at different levels of research, design, and management.

The educational objectives of the Mechanical Engineering program are:
• To educate students thoroughly in methods of analysis, including mathematical and computational skills appropriate for application to engineering problems;
• To develop the skills pertinent to the design process, including skills needed for formulation of problems, analysis, synthesis, and skills pertinent to effective communication and collaborative work;
• To teach students to use modern experimental and data analysis techniques for engineering application; and
• To prepare students for lifelong learning, nourish creative talents, and provide understanding of professional and ethical responsibilities.

Aerospace Engineering uses the basic sciences and mathematics to develop the foundation for the design, development, production, testing, and applied research associated with aerospace vehicles. These vehicles include aircraft, spacecraft, and missiles. Auxiliary and propulsion systems are also an integral part of this education. These include guidance, control, environmental, ramjet, rocket, turbojet, and piston engine systems. Emphasis in the senior year is directed toward these topics, and the program culminates in a major aerospace design project.

An agreement among southern states for sharing academic programs allows legal residents of some states to enroll in certain programs at UT (Knoxville campus) on an in-state tuition basis. The undergraduate program in Aerospace Engineering is available on an in-state basis to students from Arkansas, Kentucky, Louisiana, and South Carolina.

A coursework program leading to a minor in Aerospace Engineering for students in other engineering degree programs is also offered. The educational objectives of the Aerospace Engineering program are:
• To provide students with a comprehensive education that includes in-depth instruction in aerodynamics, structures, flight mechanics, orbital mechanics, flight propulsion, and the design of aerospace systems;
• To prepare students for professional careers in Aerospace Engineering by developing the skills pertinent to problem solving, analysis, design, and those personal skills required for teamwork and effective communication;
• To provide adequate opportunities to develop and cultivate lifelong learning skills, individual professionalism and ethics, and to nourish creative talents.

The Biomedical Engineering degree curriculum integrates selected engineering sciences and design methods with life science course work. The program prepares students for careers in a variety of health care related professions including work for medical device manufacturers and regulatory governmental agencies. The course content of the biomedical engineering curriculum complements the departmental strengths in mechanical engineering and includes a comprehensive coverage of engineering materials and biomechanics applications. Elective courses are available to allow students to specialize their curriculum to areas of particular current interest in the biomedical engineering applications. The biomedical engineering program also allows students to meet medical school admission requirements with an appropriate selection of technical electives.

The educational objectives of the biomedical engineering program are:
• To provide students with a solid foundation in mathematics, the basic and engineering sciences and engineering design methods;
• To provide students with a comprehensive integration of engineering methods of problem-solving and design within the biological sciences;
• To develop the skills needed for work in the medical device industry including a thorough coverage of engineering materials, biomaterials, biomechanics, medical device design and work in interdisciplinary teams;
• To provide essential laboratory experience with commonly used biomedical devices and systems and to provide coverage of methods for the design of experiments in medical and life science applications;
• To provide a biomedical technology-based engineering background for students desiring admission to medical school with requirements being met through the appropriate selection of elective course work.
ACADEMIC COMMON MARKET

An agreement among state for sharing academic programs allows legal residents of some states to enroll in certain programs at UT (Knoxville campus) on an in-state tuition basis. Aerospace Engineering is available on an in-state basis to students from Arkansas, Kentucky, Louisiana, and South Carolina. Biomedical Engineering is available on an in-state basis to students from Alabama, Arkansas, Kentucky, Maryland, Mississippi, South Carolina, and West Virginia.

PROGRESSION TOWARD GRADUATION

The freshman year curriculum is common to all engineering majors. The sophomore curriculum is nearly identical for all students in the department. The first two years are considered to be lower division and the two remaining years upper division. Upon completion of the lower division courses the student must apply for progression to the upper division in order to continue in the department. Students allowed to progress may be awarded Full Status or Provisional Status. Factors considered include overall grade point average, performance in lower division engineering and math courses, and evidence of orderly progression through the lower division curriculum.

Full Status

A Lower Division student may apply for progression to Upper Division after completing 47 semester hours of Lower Division engineering curriculum course work with an overall GPA of at least 2.4.

Provisional Status

Students who have completed 47 semester hours of Lower Division engineering curriculum course work with an overall GPA between 2.0 and 2.4 may apply for Provisional Status. The granting of Provisional Status is based on the availability of space in departmental programs after Full Status students have been accommodated. Provisional Status students are required to demonstrate their ability to perform satisfactorily in Upper Division by attaining a minimum GPA of 2.0 in the first 12 semester hours of 300 level required engineering courses. Award of Upper Division Full Status is dependent upon this performance.

Students with an overall GPA less than 2.0 in 47 hours of Lower Division engineering curriculum course work will not be admitted to Upper Division. Students who have not progressed to Upper Division will be dropped from departmental class rolls.

Transfer Students

Students transferring more than 26 hours from another institution are considered Transfer Students. Students transferring 47 hours or more will be admitted to Upper Division, if eligible, with Provisional Status.

Loss of Full Status

Full Status students are expected to maintain a overall GPA of 2.0 and a GPA of 2.0 in departmental courses. Failure to maintain these levels of performance will result in a review of the student’s progress and possible loss of Full Status.

Graduation Requirements

A minimum cumulative GPA of 2.0 in all departmental courses taken at UT is required for graduation. This is in addition to the University’s graduation requirements.

GRADUATE STUDY PROGRAMS

Graduate programs leading to the degrees of Master of Science and Doctor of Philosophy with a major in Mechanical Engineering or Aerospace Engineering are available to graduates of other curricula who satisfy the necessary prerequisite courses. The general requirements for advanced degrees are summarized in the Graduate Catalog.

Graduate programs leading to the degrees of Master of Sciences and Doctor of Philosophy with a major in Engineering Science are available to graduates of recognized curricula in engineering. Graduates of recognized curricula in mathematics, computer science or one of the physical or biological sciences may also qualify for admission depending upon their background. Each applicant is advised as to any prerequisite courses needed to enter a program. Program options include solid and fluid mechanics (with emphasis toward computational techniques), biomedical engineering, artificial intelligence applications, composite materials and fracture mechanics. Interdisciplinary programs are arranged to meet individual needs or interests. The student’s program of study must be approved by his or her advisory committee, and must comply with the requirements of the Graduate School.

NUCLEAR ENGINEERING

Professors

H.L. Dodds (Head), Ph.D. Tennessee, P.E.; J.T. Mihalcz (Part-time), Ph.D. Tennessee; L.F. Miller, Ph.D. Texas A&M, P.E.; R.E. Uhrig (Distinguished Professor), Ph.D. Iowa State, P.E.; B.R. Upadhyaya, Ph.D. California, P.E.

Professors (Emeritus)

T.W. Kerlin, Ph.D. Tennessee; R.E. Perez, Ph.D. Madrid; P.N. Stevens, Ph.D. Northwestern, P.E.

Research Professors

F.R. Mynatt, Ph.D. Tennessee; T.E. Shannon, Ph.D. Tennessee

Associate Professors

P.O. Groer, Ph.D. Vienna (Austria); J.W. Hines, Ph.D. Ohio State; R.E. Pevey, Ph.D., Tennessee, P.E.; T.H. Scott, Ph.D. Florida, P.E.; A.E. Ruggles, Ph.D. Rensselaer; L.W. Townsend, Ph.D. Idaho

GENERAL

Nuclear Engineering is the engineering discipline that deals with the application of nuclear and atomic processes for the benefit of mankind. Radiological Engineering is a specialty of Nuclear Engineering that focuses on biological applications. Some examples of Nuclear and Radiological Engineering are production of electric power with essentially no air pollution, production of radioisotopes for medical and industrial uses, and development of radiation-based methods for the diagnosis and treatment of cancer.

The mission of the Nuclear Engineering Department is to:

1. Produce high quality nuclear and radiological engineering graduates from undergraduate through the doctoral level in order to help meet the manpower needs of our state, region, nation, and the international community.
2. Conduct nuclear and radiological engineering related research to help meet the needs of society.
3. Perform service for industry, government, professional organizations, and the public in areas related to nuclear and radiological engineering.

Additional information about the Department and its programs is available on the Department’s web site at www.engr.utk.edu/nuclear.

BACHELOR OF SCIENCE PROGRAM

The program for the B.S. degree in Nuclear Engineering is nationally accredited by the Accreditation Board for Engineering and Technology (ABET) which is described earlier in this catalog. The educational objectives of the B.S. program are to:

1. Provide students with fundamental knowledge in mathematics, computer science, the basic sciences, and the engineering sciences that is necessary to solve state-of-the-art problems in nuclear and radiological engineering.
2. Provide students with a real-world design and analysis experience in nuclear and radiological engineering that shall include environmental, societal, safety, and economic considerations.
3. Provide students with appropriate skills in oral and written communication, teamwork, laboratory work, problem solving and the use of modern engineering tools that will prepare them to work productively in a contemporary and global environment.
4. Provide students with a diverse general education in the humanities, ethics, and social sciences to complement their technological education in order to understand and appreciate the importance of each in society and in personal development.
5. Foster a genuine desire for life-long learning in students.

Students majoring in Nuclear Engineering take courses in the basic sciences, engineering fundamentals, mathematics, computer science, humanities, and special areas of nuclear engineering including fission system design and safety; radiation transport and shielding; heat transfer and fluid flow; instrumentation and controls; fuel cycle and waste management; and health physics. Nuclear Engineering students may concentrate in Radiological Engineering by substitution of three courses. The Radiological Engineering concentration also satisfies most of the requirements of pre-med, pre-vet, and pre-dentistry programs.

MASTER OF SCIENCE PROGRAM

A graduate program leading to a degree of Master Science is available to graduates of recognized undergraduate curricula in engineering, physics, chemistry, or mathematics. Each applicant will be advised as to the necessary prerequisite courses before entering the program. The general requirements of the master’s degree are summarized in the Graduate Catalog.
DOCTORAL PROGRAM
A program leading to the Ph.D. degree is available in nuclear engineering. For details, see the Graduate Catalog.

ACADEMIC COMMON MARKET
An agreement among states for sharing academic programs allows legal residents of some states to enroll in certain programs at UT (Knoxville campus) on an in-state tuition basis. The undergraduate program in Nuclear Engineering is available on an in-state basis to students from Alabama, Arkansas, Delaware, Kentucky, Louisiana, Mississippi, South Carolina, Virginia and West Virginia.

CURRICULA
Course requirements for the various engineering curricula are listed on the following pages. The numbers in the columns indicate the number of semester hours of credit for each course. Individual course prerequisites should be strictly adhered to, even if courses are not taken in the semester indicated. Although the requirements for each degree can be completed in four academic years (five for the cooperative program), the quality of the learning experience is much more important than the speed with which the curricula are completed.

Questions about individual courses should be directed to the department responsible for the course; questions about a particular curriculum should be directed to the major department.

Prerequisites
Before registering for any engineering course, a student should make certain that any necessary background work has been completed. In addition to specific prerequisites listed, it is assumed that a student taking sophomore engineering courses has completed all freshman courses, whether specifically listed as a prerequisite or not. When this is not the case, a student should seek advice from the advisor or department responsible for the course in question before registration so as to minimize the chances of academic difficulty. Students who do not have prescribed prerequisites may be dropped from a course at any time during a semester when the lack of prerequisites is discovered.

FRESHMAN YEAR
The following freshman year curriculum is common to all engineering programs except Engineering Physics. (Engineering Physics students should see the curriculum that follows.)

<table>
<thead>
<tr>
<th>Course Requirements</th>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>English 101, 102</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry 120, 120</td>
<td>6</td>
</tr>
<tr>
<td>Mathematics 141, 142</td>
<td>8</td>
</tr>
<tr>
<td>Engineering Fundamentals 101, 102</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>34 hours</strong></td>
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</tbody>
</table>

AEROSPACE ENGINEERING

<table>
<thead>
<tr>
<th>Sophomore</th>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics 231, 241</td>
<td>7</td>
</tr>
<tr>
<td>Mathematics 200</td>
<td>4</td>
</tr>
<tr>
<td>Physics 231, 232</td>
<td>4</td>
</tr>
<tr>
<td>Engineering Science 231, 321</td>
<td>6</td>
</tr>
<tr>
<td>Materials Science and Engineering 201</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical Engineering 331</td>
<td>3</td>
</tr>
<tr>
<td>Economics 201</td>
<td>4</td>
</tr>
<tr>
<td>1 General Education Elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Junior</strong></td>
<td><strong>15 hours</strong></td>
</tr>
<tr>
<td>Mechanical Engineering 332, 363, 391</td>
<td>9</td>
</tr>
<tr>
<td>Aerospace Engineering 345, 351, 363, 370</td>
<td>12</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 301, 302</td>
<td>6</td>
</tr>
<tr>
<td>Engineering Science 341</td>
<td>3</td>
</tr>
<tr>
<td>1 General Education Electives</td>
<td>6</td>
</tr>
<tr>
<td><strong>Senior</strong></td>
<td><strong>15 hours</strong></td>
</tr>
<tr>
<td>Mechanical Engineering 344, 451, 402</td>
<td>7</td>
</tr>
<tr>
<td>Aerospace Engineering 426, 429</td>
<td>3</td>
</tr>
<tr>
<td>Aerospace Engineering 422, 424, 425</td>
<td>9</td>
</tr>
<tr>
<td>1 General Education Electives</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>135 hours</strong></td>
</tr>
</tbody>
</table>

1General Education Electives: minimum of 14 hours required. (See College of Engineering General Requirements.)

BIOMEDICAL ENGINEERING

<table>
<thead>
<tr>
<th>Sophomore</th>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics 231, 232</td>
<td>7</td>
</tr>
<tr>
<td>Math 241, 231, 200</td>
<td>8</td>
</tr>
<tr>
<td>Engineering Science 231, 321</td>
<td>6</td>
</tr>
<tr>
<td>Biomedical Engineering 271</td>
<td>3</td>
</tr>
<tr>
<td>Biology 130, 140</td>
<td>3</td>
</tr>
<tr>
<td>Materials Science and Engineering 201</td>
<td>3</td>
</tr>
<tr>
<td>1 Technical Electives</td>
<td>6</td>
</tr>
<tr>
<td><strong>Junior</strong></td>
<td><strong>15 hours</strong></td>
</tr>
<tr>
<td>1 Technical Electives</td>
<td>6</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 301</td>
<td>3</td>
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<tr>
<td>Engineering Science 341</td>
<td>3</td>
</tr>
<tr>
<td>Biomedical Engineering 300</td>
<td>3</td>
</tr>
<tr>
<td>Materials Science and Engineering 473</td>
<td>3</td>
</tr>
<tr>
<td>Economics 201</td>
<td>4</td>
</tr>
<tr>
<td>Mechanical Engineering 331</td>
<td>3</td>
</tr>
<tr>
<td>Biomedical Engineering 301, 310, 346</td>
<td>7</td>
</tr>
<tr>
<td>Philosophy 345</td>
<td>3</td>
</tr>
<tr>
<td><strong>Senior</strong></td>
<td><strong>15 hours</strong></td>
</tr>
<tr>
<td>Biomedical Engineering 455, 430, 431</td>
<td>6</td>
</tr>
<tr>
<td>Engineering Electives</td>
<td>6</td>
</tr>
<tr>
<td>General Education Elective</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical Engineering 402</td>
<td>3</td>
</tr>
<tr>
<td>Biomedical Engineering 469</td>
<td>4</td>
</tr>
<tr>
<td>Biomedical Engineering Elective</td>
<td>3</td>
</tr>
<tr>
<td>General Education Electives</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>135 hours</strong></td>
</tr>
</tbody>
</table>

CHEMICAL ENGINEERING

<table>
<thead>
<tr>
<th>Sophomore</th>
<th>Hours Credit</th>
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</thead>
<tbody>
<tr>
<td>Chemical Engineering 200, 230, 240, 250</td>
<td>14</td>
</tr>
<tr>
<td>Chemistry 310-319</td>
<td>4</td>
</tr>
<tr>
<td>Materials Science and Engineering 201</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics 200, 231, 241</td>
<td>8</td>
</tr>
<tr>
<td>General Education Electives</td>
<td>6</td>
</tr>
</tbody>
</table>
| 1 Chemical Engineering CIVIL ENGINEERING

<table>
<thead>
<tr>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 241</td>
</tr>
<tr>
<td>Math 231</td>
</tr>
<tr>
<td>Physics 231</td>
</tr>
<tr>
<td>Statistics 251</td>
</tr>
<tr>
<td>Nuclear Engineering 200</td>
</tr>
<tr>
<td>Civil Engineering 205, 210, 261</td>
</tr>
<tr>
<td>1 General Education Electives</td>
</tr>
<tr>
<td><strong>Junior</strong></td>
</tr>
<tr>
<td>Chemical Engineering 321, 351, 361, 390</td>
</tr>
<tr>
<td>Civil Engineering 305, 330, 352, 380, 395</td>
</tr>
<tr>
<td><strong>Senior</strong></td>
</tr>
<tr>
<td>Civil Engineering 435, 442, 471, 480</td>
</tr>
<tr>
<td>Civil Engineering 400, 401, 440</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
</tr>
</tbody>
</table>

1See College list of approved courses. All electives must be pre-approved by the advisor and department head.

CIVIL ENGINEERING

<table>
<thead>
<tr>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics 231, 241, 251</td>
</tr>
<tr>
<td>Physics 231</td>
</tr>
<tr>
<td>Computer Science 102</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 201</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 202, 251</td>
</tr>
<tr>
<td>Computer Science 140</td>
</tr>
<tr>
<td>Mathematics 241</td>
</tr>
<tr>
<td>1 General Education Elective</td>
</tr>
<tr>
<td><strong>Junior</strong></td>
</tr>
<tr>
<td>Electrical and Computer Engineering 310, 311, 331</td>
</tr>
<tr>
<td>Computer Science 302</td>
</tr>
<tr>
<td>Mathematics 300</td>
</tr>
<tr>
<td>1 Computer Engineering Junior Electives</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 351</td>
</tr>
<tr>
<td>Computer Science 360</td>
</tr>
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<td><strong>Total:</strong></td>
</tr>
</tbody>
</table>

1At least one General Education course must be from the Professional and Ethical Responsibility cluster.

COMPUTER ENGINEERING

<table>
<thead>
<tr>
<th>Hours Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics 231, 251</td>
</tr>
<tr>
<td>Computer Science 102</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 201</td>
</tr>
<tr>
<td>Electrical and Computer Engineering 202, 251</td>
</tr>
<tr>
<td>Computer Science 140</td>
</tr>
<tr>
<td>Mathematics 241</td>
</tr>
<tr>
<td>1 General Education Elective</td>
</tr>
<tr>
<td><strong>Senior</strong></td>
</tr>
<tr>
<td>Electrical and Computer Engineering 451</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
</tr>
</tbody>
</table>
**ELECTRICAL ENGINEERING**

**Sophomore**
- Electrical and Computer Engineering 201, 205 ........ 6
- Mathematics 231 .................................................. 6
- Physics 231 .......................................................... 3
- Electrical and Computer Engineering 202, 251 ....... 7
- General Education Elective ................................. 3
- Mathematics 541 .................................................. 3
- Physics 232 .......................................................... 4

**Junior**
- Electrical and Computer Engineering 310, 311, 331, 341, 351 .................................................. 15
- General Education Elective ................................. 3
- Electrical and Computer Engineering 312, 321, 332, 342, 395 .................................................. 13
- General Education Elective ................................. 3

**Senior**
- Electrical and Computer Engineering 400 .............. 5
- Electrical Engineering Senior Electives ................. 13
- General Education Electives ............................... 9
- Mechanical Engineering 331 ................................ 3
- Nuclear Engineering 342, Engineering Science 231, or Material Science and Engineering 410 ............... 3

Total: 134 hours

1At least one General Education course must be from the Professional and Ethical Responsibility cluster.
2The electrical engineering senior electives must meet the depth and breadth requirements. The depth requirement is met by taking two courses in one of the core areas: systems (ECE 411, 412), power (ECE 421, 422), electronics (ECE 431, 432), communications (ECE 441, 442), and computer (ECE 451, 452). The breadth requirement is met by taking courses in other core areas, or courses in computer vision, power electronics, and emerging technologies. Electives are approved by the student's faculty advisor.

**INDUSTRIAL ENGINEERING**

**Sophomore**
- English Electives ................................................. 6
- Math 200, 231, 241 .................................................. 8
- Engineering Science 231 ....................................... 3
- Industrial Engineering 202 ................................... 3
- Accounting 203 ..................................................... 3
- Statistics 251 ....................................................... 3
- Materials Science and Engineering 201 ............... 3

**Junior**
- Electrical and Computer Engineering 301 .......... 9
- Industrial Engineering 300, 301, 304, 310 ............. 13
- Economics 201 .................................................. 4
- Nuclear Engineering 342 ....................................... 3
- General Education Elective ................................. 3

**Senior**
- Industrial Engineering 306, 401, 402, 403, 404 ........ 14
- Industrial Engineering 405, 421, 422, 440 ............. 12
- Technical Elective ............................................... 3
- General Education Electives ............................... 6

Total: 134 hours

**MATERIALS SCIENCE AND ENGINEERING**

**Sophomore**
- Materials Science and Engineering 201, 290, 291 1 .... 4
- Physics 231, 232 .................................................. 7
- Mathematics 200, 231, 241 ................................... 8
- Chemical Engineering 200, 240 ............................. 9
- General Education Electives ............................... 6

**Junior**
- Materials Science and Engineering 290, 291 2, 300, 301, 302, 304, 320, 340, 360, 369 .............. 19
- Chemistry 473 ................................................... 3
- Electrical and Computer Engineering 301 ............. 3
- Engineering Science 321 ....................................... 3

**Senior**
- Materials Science and Engineering 290, 291 1, 380, 402, 405, 410, 421, 489, 493, 494, 495, 496 .... 20
- Materials Science and Engineering Elective ........... 3
- Technical Elective ............................................... 3
- General Education Electives ............................... 6

Total: 133 hours

1General Education courses must include Economics 201 and one course from the Effective Communications Cluster in addition to the requirements described under Approved General Education Electives.
2MSE electives: 422, 429, 443, 444, 470, 472, 474, 475, 494, 495, 496
3Students must enroll in 290 and 291 every year beginning with the sophomore year.

**MECHANICAL ENGINEERING**

**Sophomore**
- Mathematics 241, 231, 200 ................................... 8
- Physics 231, 232 .................................................. 7
- Engineering Science 231, 321 ................................ 6
- Materials Science and Engineering 201 ............... 3
- Mechanical Engineering 331 ................................ 3
- Economics 201 .................................................. 4
- General Education Electives ............................... 2

**Junior**
- Mechanical Engineering 391, 344, 363, 366, 345, 332, 365 ........................................... 21
- Electrical and Computer Engineering 301, 302 .... 6
- Engineering Science 341 ....................................... 6
- General Education Electives ............................... 6

**Senior**
- Mechanical Engineering 402, 451, 466, 475, 449, 431 .................................................. 14
- Mechanical Engineering 451 and 469 or 456 and 479 .................................................. 6
- Technical Elective .................................................. 3
- Technical Elective (to be selected from ES 452, AE 351, IE 300) ......................................... 3
- General Education Electives ............................... 6

Total: 135 hours

**NUCLEAR ENGINEERING**

**Sophomore**
- Mathematics 200, 231, 241 ................................... 8
- Physics 231, 232 .................................................. 7
- Nuclear Engineering 200, 203 ................................ 4
- Electrical Engineering 301 .................................. 3
- Computer Science 102 ......................................... 4
- General Education Electives ............................... 9

**Junior**
- Physics 341 .......................................................... 3
- Nuclear Engineering 301, 304, 342, 351, 360, 431, 470 .................................................. 21
- Materials Science and Engineering 201 ............... 3
- General Education Electives ............................... 3

**Senior**
- Industrial Engineering 405 .................................. 3
- Mechanical Engineering 402 ................................ 1
- Nuclear Engineering 400, 403, 404, 406, 472 ......... 14
- Technical Elective .................................................. 6
- General Education Electives ............................... 6

Total: 129 hours

**NUCLEAR ENGINEERING: RADIOLOGICAL ENGINEERING CONCENTRATION**

**Sophomore**
- Mathematics 200, 231, 241 ................................... 8
- Physics 231, 232 .................................................. 7
- Nuclear Engineering 200, 203 ................................ 4
- Electrical Engineering 301 .................................. 3
- Computer Science 102 ......................................... 4
- General Education Electives ............................... 9

**Junior**
- Physics 341 .......................................................... 3
- Nuclear Engineering 301, 304, 342, 351, 360, 431, 470 .................................................. 18
- Biology 140 .......................................................... 4
- Biochemistry and Cellular and Molecular Biology (BCMB) 230 ........................................ 5
- General Education Electives ............................... 3

**Senior**
- Industrial Engineering 405 .................................. 3
- Mechanical Engineering 402 ................................ 1
- Nuclear Engineering 400, 403, 404, 406, 472 ......... 14
- Technical Elective .................................................. 3
- General Education Electives ............................... 6

Total: 132 hours

1General Education Electives must include one course from the Communications Cluster and one course from the Professional and Ethical Responsibility Cluster.
2Technical electives are selected from upper division mathematics and engineering courses and must be pre-approved by the department.

**Nuclear Engineering: Radiological Engineering Concentration**

**Sophomore**
- Mathematics 200, 231, 241 ................................... 8
- Physics 231, 232 .................................................. 7
- Nuclear Engineering 200, 203 ................................ 4
- Electrical Engineering 301 .................................. 3
- Computer Science 102 ......................................... 4
- General Education Electives ............................... 9

**Junior**
- Physics 341 .......................................................... 3
- Nuclear Engineering 301, 304, 342, 351, 360, 431, 470 .................................................. 18
- Biology 140 .......................................................... 4
- Biochemistry and Cellular and Molecular Biology (BCMB) 230 ........................................ 5
- General Education Electives ............................... 3

**Senior**
- Industrial Engineering 405 .................................. 3
- Mechanical Engineering 402 ................................ 1
- Nuclear Engineering 400, 403, 404, 406, 472 ......... 14
- Technical Elective .................................................. 3
- General Education Electives ............................... 6

Total: 132 hours

1General Education Electives must include one course from the Communications Cluster and one course from the Professional and Ethical Responsibility Cluster.
2Technical electives are selected from upper division mathematics and engineering courses and must be pre-approved by the department.

**Engineering Sciences**

**Freshman**
- Mathematics 117 .................................................. 8
- Engineering 100 ................................................... 8
- English 101 .......................................................... 6

**Sophomore**
- Mathematics 231 .................................................. 9
- Physics 231 .......................................................... 4
- Physics 232 .......................................................... 4
- Physics 241 .......................................................... 4

**Junior**
- Physics 311 .......................................................... 6
- Physics 361 .......................................................... 6
- Physics 421 .......................................................... 4
- Physics 422 .......................................................... 4

**Senior**
- Physics 411 .......................................................... 6
- Physics 431 .......................................................... 6
- Physics 432 .......................................................... 6

Total: 134 hours

1Transfer students from other engineering departments may substitute Engineering Fundamentals 102 for Physics 137, Physics 231 for Physics 138, and Physics 232 for Physics 240.
2A total of 12 hours of engineering electives plus 9 hours of technical electives are required. Engineering electives should form a coherent group of courses taken in the College of Engineering. Technical electives may be taken in physics, engineering, math, other physical sciences, or astronomy.