

College of Engineering and Applied Sciences

Peter E. Crouch, Ph.D.
Dean



Interior of the Noble Science and Engineering Library

John Maclsaac photo

Del E. Webb School of Construction	202	Department of Electrical Engineering	235
School of Engineering	206	Department of Industrial and Management Systems Engineering	240
Department of Chemical, Bio, and Materials Engineering	210	Department of Mechanical and Aerospace Engineering	244
Department of Civil and Environmental Engineering	222	Programs in Engineering Special Studies	251
Department of Computer Science and Engineering	228		

PURPOSE

The purpose of the College of Engineering and Applied Sciences is to provide students with a range of educational opportunities by which they may achieve competence in the major branches of engineering, in computer science, and construction. Considerable effort is spent on the development and delivery of well-rounded programs that enhance student preparation for professional careers, lifelong learning, and responsible participation as a member of society.

For more information, visit the college's Web site at www.eas.asu.edu.

ORGANIZATION

The College of Engineering and Applied Sciences is composed of the following academic and service units (with six departments making up the School of Engineering):

Del E. Webb School of Construction

School of Engineering

Department of Chemical, Bio, and Materials Engineering

Department of Civil and Environmental Engineering

Department of Computer Science and Engineering

Department of Electrical Engineering

Department of Industrial and Management Systems Engineering

Department of Mechanical and Aerospace Engineering

Research Centers. The college is committed to the development of research programs of national prominence and to the concept that research is an important part of its educational role. The college encourages the participation of both qualified undergraduate students and graduate students in various research activities. Most of the faculty are involved in government or industry-sponsored research programs in a wide variety of topics. A partial list of these topics includes aerodynamics, biotechnology, computer design, computer-integrated manufacturing, environmental fluid dynamics, innovative engineering education, microelectronics manufacturing, power systems, semiconductor materials and devices, signal processing, solar energy, solid-state electronic devices, structural dynamics, telecommunications, thermosciences, and transportation systems. This research is carried out in the departments and schools listed above and in the following interdisciplinary research centers:

Center for Innovation in Engineering Education

Center for Low Power Electronics

Center for Research in Engineering and Applied Sciences

Center for Solid-State Electronics Research

Manufacturing Institute

Center for System Science and Engineering Research

Telecommunications Research Center

Center for Professional Development. The Center for Professional Development, often in cooperation with the college's academic units and research centers, provides a variety of technical conferences, seminars, short courses, and televised and satellite-transmitted programs to enable engineers, scientists, and managers to continue the lifelong learning that is so necessary in a constantly changing world.

Programs may be conducted on campus, at various off-campus locations, or at company sites upon request. For more information, contact the Center for Professional Development, located in ECG 148, at 480/965-1740, by

e-mail at asu.cpd@asu.edu, or visit the center's Web site at www.eas.asu.edu/cpd.

ADMISSION

Individuals wishing to be admitted to freshman standing in the College of Engineering and Applied Sciences should have completed certain secondary-school units. These units are identified in the requirements for each of the two schools in the college. If these conditions are not met, additional university course work, possibly unacceptable for degree credit, may be required.

Students who are not admissible to programs in this college and who enroll in another college at ASU may not register for any 300- or 400-level courses in this college unless they are required in their degree programs and the students have the proper course prerequisites.

Entrance requirements of this college may differ from those of other ASU academic units. Students may be admitted under one of two different classifications, professional or preprofessional.

Professional Status. For admission to professional status, Arizona residents and nonresidents must meet one of the requirements as listed in the appropriate section of the "Professional Status Requirements for Residents" table, page 197. In addition, an international student must satisfy minimum Test of English as a Foreign Language (TOEFL) score requirements as shown in the table.

Students admitted to the university after successful completion of the General Education Development (GED) examination are admitted as preprofessional students within their major. Professional status is attained by meeting the minimum ACT or SAT score required for admission as listed in the "Professional Status Requirements" table, page 197.

Preprofessional Status. A student not admissible to professional status within the college but otherwise regularly admissible to ASU as stated in "Undergraduate Admission," page 40, may be admitted as a *preprofessional* student to any one of the academic programs of the college. International students whose TOEFL scores do not meet the required minimum shown in the tables below may also be admitted to preprofessional status. A student admitted into this classification follows the freshman-sophomore sequence of courses as required by the chosen major. Courses are selected with the assistance of an academic advisor. After completing a minimum of 30 semester hours of required or approved elective courses *with a cumulative GPA equivalent to that required of transfer students and corresponding to the chosen major*, students may apply for admission to professional status. International students must also submit a TOEFL score equivalent to that required for admission to professional status (see the "Professional Status Requirements" table, page 197). Preprofessional students are not permitted to register for 300- and 400-level courses in the College of Engineering and Applied Sciences until their status is changed to the professional classification.

Readmission. Students applying for readmission to professional status for any program in this college must have a cumulative GPA for all college course work equal to that of

Professional Status Requirements

School	High School Rank	Minimum Scores			Transfer GPA ¹	
		ACT	SAT	TOEFL ²	Resident	Nonresident
Residents						
Construction	Upper 25%	23	1140			
Engineering	Upper 25%	23	1140			
Nonresidents and International Students						
Construction	Upper 25%	24	1140	550		
Engineering	Upper 25%	24	1140	550		
Transfer Students						
Construction				550	2.25	2.50
Engineering				550	2.50	2.50

¹ The cumulative GPA is calculated using all credits from ASU as well as those from other colleges and universities.

² This test is for international students (see "TOEFL," page 19).

the transfer admission requirements shown in the appropriate section of the "Professional Status Requirements" table.

Transfer into and Within the College. Students transferring between academic programs within the college or from other colleges within the university must meet both the cumulative GPA requirement and the catalog requirements of the desired program in effect at the time of transfer. Students who are transferring from an Arizona community college and have been in continuous residence may continue under the catalog in effect at the time of their entrance into the community college.

Transfer Students. A student who contemplates transferring into this college from another institution, whether a community college or four-year institution, should carefully study the catalog material pertaining to the particular program and consult an advisor in this college before enrolling in the other institution. These steps assure a smooth transition at the time of transfer. Transfer students may request admission to either preprofessional or professional status in any of the programs offered by this college.

The minimum requirements for admission of resident, nonresident, and international transfer students to the professional program are listed in the table, "Professional Status Requirements for Transfer Students." The academic units may impose additional admission and graduation requirements beyond the minimum specified by the college.

Credit is granted for transferred courses deemed equivalent to corresponding courses in the selected program of study, subject to grade and ASU resident credit requirements. No grades lower than "C" are accepted as transfer credit to meet the graduation requirements of this college. Credits transferred from a community college or two-year institution are applied only as lower-division credits. For a listing of the acceptable courses transferable to the various college degree programs, prospective Arizona community college transfer students should consult their advisors and refer to the ASU transfer guides available on the Web at www.asu.edu/provost/articulation.

It should be noted that some courses taken in other colleges of this university or other universities may be acceptable for general university credit but may not be acceptable toward the degree requirements of this college.

Determination of those particular courses acceptable to a specific degree program is made within the appropriate academic unit with the approval of the dean.

Cooperative Education. The co-op program is a work-study plan of education that alternates periods of academic study with periods of employment in business, industry, or government. Students who choose this program ideally complete 12 months of employment and graduate with both the academic background and practical experience gained from working with professionals in a chosen field.

A student in the college is eligible to apply to the co-op program upon completion of 45 or more hours of classes required for the selected major. Transfer students are required to complete at least one semester at ASU before beginning work. All student applicants must have a GPA of at least 2.50 and the approval of an advisor.

To maintain continuous student status in the university, each co-op student must be enrolled in ASE 399 Cooperative Work Experience for one semester hour during each work session. Such credit cannot be applied toward degree requirements. For more information, contact the director of Student Academic Services at 480/965-1750 (ECG 102) or the Career Services office at 480/965-2350 (SSV C359).

ADVISING

For assistance and counseling in planning a program of study, each student in this college is assigned a faculty advisor who is familiar with the chosen field of specialization and who must be consulted before registering each semester. The student should inform the advisor of any outside work or activity so that course loads may be adjusted accordingly.

Most students attending college find it necessary to obtain part-time employment; consequently, it is suggested that a careful balance of work and class requirements be considered in order to avoid academic problems.

Students enrolled in this college may register for a maximum of 19 semester hours each semester. Any student wanting to register for more than the maximum must petition the CEAS Standards Committee and must have an approval on file before registering for the overload.

College of Engineering and Applied Sciences Baccalaureate Degrees and Majors

Major	Degree	Administered by
Del E. Webb School of Construction		
Construction ¹ Options: general building construction, heavy construction, residential construction, specialty construction	B.S.	Del E. Webb School of Construction
School of Engineering		
Aerospace Engineering ¹ Emphases: aerodynamics, aerospace materials, aerospace structures, computer methods, design, mechanical, propulsion, system dynamics and control	B.S.E.	Department of Mechanical and Aerospace Engineering
Bioengineering ¹ Emphases: biochemical engineering, bioelectrical engineering, biomaterials engineering, biomechanical engineering, biomedical imaging engineering, biosystems engineering, molecular and cellular bioengineering, premedical engineering	B.S.E.	Department of Chemical, Bio, and Materials Engineering
Chemical Engineering ¹ Emphases: biochemical, biomedical, environmental, materials, premedical, process engineering, semiconductor processing	B.S.E.	Department of Chemical, Bio, and Materials Engineering
Civil Engineering ¹ Option: environmental engineering	B.S.E.	Department of Civil and Environmental Engineering
Computer Science ¹	B.S.	Department of Computer Science and Engineering
Computer Systems Engineering ¹	B.S.E.	Department of Computer Science Engineering
Electrical Engineering ¹	B.S.E.	Department of Electrical Engineering
Engineering Interdisciplinary Studies ²	B.S.	School of Engineering
Engineering Special Studies ¹ Option: premedical engineering	B.S.E.	School of Engineering
Industrial Engineering ¹	B.S.E.	Department of Industrial and Management Systems Engineering
Materials Science and Engineering ¹ Emphases: biomaterials, ceramic materials, energy systems, integrated circuit materials, manufacturing and materials processing, mechanical metallurgy, metallic materials systems, polymers and composites	B.S.E.	Department of Chemical, Bio, and Materials Engineering
Mechanical Engineering ¹ Emphases: aerospace; biomechanical; computer methods; control and dynamic systems; design; energy systems; engineering mechanics; manufacturing; stress analysis, failure prevention, and materials; thermosciences	B.S.E.	Department of Mechanical and Aerospace Engineering

¹ This program is also hosted at ASU East.

² Applications for this program are not being accepted at this time.

DEGREES

The faculty in the College of Engineering and Applied Sciences offer programs leading to the B.S. and B.S.E. degrees with majors in the subjects shown in the "College of Engineering and Applied Sciences Baccalaureate Degrees and Majors" table, page 198. Each major is administered by the academic unit indicated.

Integrated B.S.E.—M.S. Program. To provide greater program flexibility, qualified students of the School of Engineering may undertake a program with an integrated fourth- and fifth-year sequence of study in one of several fields of specialization in engineering. This program provides an

opportunity to meet the increasing demands of the profession for graduates who can begin their engineering careers at an advanced level.

Students admitted to this program are assigned a faculty committee that supervises a program of study in which there is a progression in the course work and in which earlier work is given application in the later engineering courses for both the bachelor's and master's degrees. Entry into the integrated program requires an application submitted to the dean through the faculty advisor and the department chair. Applications are reviewed by a school committee that recommends the appropriate action to the dean. The application may be submitted in the fifth semester.

GRADUATE PROGRAMS

The faculty in the College of Engineering and Applied Sciences offer a Master of Computer Science (M.C.S.) degree; a Master of Science (M.S.) degree with majors in Computer Science, Construction, and Engineering Science; a Master of Science in Engineering (M.S.E.) degree; and a Ph.D. degree in Engineering or Computer Science. The faculty in the Department of Industrial and Management Engineering also participate with the American Graduate School of International Management (Thunderbird) to offer the Master of Science in Engineering (Industrial Engineering)/Master of International Management of Technology. For more information, see the "College of Engineering and Applied Sciences Graduate Degrees and Majors" table, page 200.

School of Engineering faculty participate in offering the Master of Engineering (M.E.) as a collaborative degree program offered by Arizona's three state universities.

For more information on courses, faculty, and programs, see the *Graduate Catalog*.

DEGREE REQUIREMENTS

For detailed information on the degree requirements of a major in the College of Engineering and Applied Sciences, refer to that department's or school's individual description on the following pages.

UNIVERSITY GRADUATION REQUIREMENTS

In addition to department and school requirements, students must meet all university graduation requirements (see "University Graduation Requirements," page 81). A well-planned program of study enables students to meet all requirements in a timely fashion. Students are encouraged to consult with an academic advisor in planning a program to ensure that they comply with all necessary requirements.

General Studies Requirement

All students enrolled in a baccalaureate degree program must satisfy a university requirement of a minimum of 35 hours of approved course work in General Studies. General Studies courses are listed in the "General Studies Courses" table, page 89, in the course descriptions, in the *Schedule of Classes*, and in the *Summer Sessions Bulletin*. Note that all three General Studies awareness areas are required. Consult your advisor for an approved list of courses.

First-Year Composition Requirement

As a minimum, completion of ENG 101 and 102, or ENG 107 and 108, or ENG 105 with grades of "C" or higher is required for graduation from ASU in any baccalaureate program. See "First-Year Composition Requirement" on page 81. Any student whose written or spoken English in any course is unsatisfactory may be required by the appropriate director or department chair to take additional course work.

COLLEGE DEGREE REQUIREMENTS

Pass/Fail Grades

Students enrolled in the College of Engineering and Applied Sciences do not receive degree credit for pass/fail courses taken at this institution. In addition, no course in this college is offered for pass/fail credit. Students requesting credit for pass/fail courses taken at another institution

must file a Petition for Adjustment to Curriculum Requirements. Each request is judged on its particular merits.

Entry into Upper-Division Courses

Before enrolling in courses at the 300 level and above, students must be in good academic standing in professional program status and have the approval of their advisors. A student who is not in good academic standing must secure approval from his or her advisor and the college's Student Academic Services. Students whose grades in 300-level courses are unsatisfactory may be required to retake one or more courses for which credit has previously been granted.

The departments and schools have certain additional requirements that must be met in addition to the above college requirements and students should consult them for details.

Currency of Course Work

Courses taken more than five years before admission to degree programs in this college are not normally accepted for transfer credit at the option of the department in which the applicant wishes to enroll. Courses completed within the five years preceding admission are judged as to their applicability to the student's curriculum.

MAJOR REQUIREMENTS

For detailed information on the degree requirements of a major in the College of Engineering and Applied Sciences, refer to that department's or school's individual description on the following pages.

ACADEMIC STANDARDS

Retention. A student is expected to make satisfactory progress toward completion of degree requirements in order to continue enrollment in the College of Engineering and Applied Sciences. Any one of the following conditions is considered unsatisfactory progress and results in the student being placed on probationary status:

1. a semester or summer session with a GPA less than or equal to 1.50;
2. two successive semesters with GPAs less than 2.00; or
3. an ASU cumulative GPA less than 2.00.

Students on probation are subject to disqualification if (1) they do not attain a semester GPA of 2.25; (2) their cumulative GPA is below 2.00 at the end of the probationary semester; or (3) they are placed on probation for two consecutive semesters.

Courses completed during the summer sessions may not be used to reevaluate a student's fall semester probationary status.

Students on academic probation are not allowed to register for more than 13 semester hours of course work. Probationary students may not register for the next semester without a special permit from an advisor in Student Academic Services. Special permits are not given until grades are recorded by the registrar for the current semester.

Disqualification. During a semester on academic probation, a student who fails to meet the retention standards specified above is disqualified. Students may request a review of their disqualification status by contacting the associate director of Student Academic Services in ECG 102. Any disqualified student who is accepted by another college at ASU may not

College of Engineering and Applied Sciences Graduate Degrees and Majors

Major	Degree	Administered by
Del E. Webb School of Construction		
Construction Concentrations: construction science, facilities, management	M.S.	Del E. Webb School of Construction
School of Engineering		
Aerospace Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Bioengineering	M.S., Ph.D.	Department of Chemical, Bio, and Materials Engineering
Chemical Engineering Concentrations: biomedical and clinical engineering, chemical process engineering, chemical reactor engineering, energy and materials conversion, environmental control, solid-state processing, transport phenomena	M.S., M.S.E., Ph.D.	Department of Chemical, Bio, and Materials Engineering
Civil Engineering	M.S., M.S.E., Ph.D.	Department of Civil and Environmental Engineering
Computer Science	M.C.S., M.S., Ph.D.	Department of Computer Science and Engineering
Electrical Engineering	M.S., M.S.E., Ph.D.	Department of Electrical Engineering
Engineering	M.E.	School of Engineering ¹
Engineering Science	M.S., M.S.E., Ph.D.	School of Engineering
Industrial Engineering	M.S., M.S.E., Ph.D.	Department of Industrial and Management Systems Engineering
Mechanical Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Science and Engineering of Materials Concentrations: high-resolution nanostructure analysis, solid-state device materials design	Ph.D. ²	Committee on the Science and Engineering of Materials

¹ This collaborative program is offered by the three state universities. Refer to the 1999–2000 *Graduate Catalog* for more information.

² This program is administered by the Graduate College. See “Graduate College,” page 301.

register for courses in this college unless the courses are required for the new major. Disqualified students who do register for courses in this college may be withdrawn from these courses any time during that semester. Furthermore, students at the university who have been disqualified academically by this college are not eligible to enroll in summer session courses in this college until the disqualification period has expired and they have been reinstated.

Reinstatement. The College of Engineering and Applied Sciences does not accept an application for reinstatement until the disqualified student has remained out of this college for at least a 12-month period. Merely having remained in a disqualified status for this period of time does not, in itself, constitute a basis for reinstatement. Proof of ability to do satisfactory college work in the chosen discipline is required, for example, completing at least 15 semester hours of pertinent courses in the discipline at a community college with higher than average grades, and a cumulative GPA of 2.50 or higher for all courses completed.

STUDENT RESPONSIBILITIES

Course Prerequisites. Students should consult the *Schedule of Classes* and the catalog for course prerequisites. Students who register for courses without the designated prerequisites may be withdrawn without the student’s con-

sent at any time before the final examination. Such withdrawal may be initiated by the instructor, the chair of the department offering the course, the director of Student Academic Services, or the dean of the college. In such cases, students will not receive monetary reimbursement. However, such withdrawal is considered to be unrestricted as described under “Grading System,” page 73, and does not count against the number of restricted withdrawals allowed.

SPECIAL PROGRAMS

Foundation Coalition. ASU is a member of the Foundation Coalition, a National Science Foundation-funded group of seven institutions of higher learning across the U.S. that is working to improve engineering education. Foundation Coalition programs are intended to

1. demonstrate and promote the interrelationships of subject matter within the curriculum;
2. improve the interpersonal skills of students and the understanding of concepts through the use of concepts through the use of more teaming and cooperative learning environments;
3. increase the use of technology in the curriculum; and
4. assess and evaluate intended improvements.

Such changes address the desires of employers, increase the numbers of baccalaureate degrees earned by members of currently underrepresented groups, and promote curriculum improvement. Foundation Coalition improvements are presently available to all freshmen and sophomores except those in Chemical, Bio, and Materials Engineering, and to juniors and seniors in Electrical Engineering and Industrial and Management Systems Engineering.

Foundation Coalition programs offer students a more hands-on, team-based, computer-intensive approach to the curriculum. The freshman programs provide an important opportunity for new students to get to know a small group of students, making a large university seem less overwhelming. The programs also involve more interactions with faculty and access to special tutors. All students will get a team-based, computer-intensive education in ECE 100, Introduction to Engineering Design, but the Foundation Coalition program extends this experience to many more subjects and courses.

Freshmen Foundation Coalition programs offer both an integrated set of courses which include engineering, calculus, physics, and English in both the first and second semesters, and smaller integration packages that include engineering and English. In these packages, the same set of students take all of the courses in the package in high-tech, team-promoting classrooms while the faculty work together to deliver a unified set of courses. Sophomore programs presently involve courses in mathematics, mechanics, and electrical circuits.

Students interested in these programs should see their department advisor or inquire in the office of the Center for Innovation in Engineering Education in room ECG 205 or call 480/965-5350, or access the Web site at www.eas.asu.edu/~asufc.

Minority Engineering Program. The staff of the Minority Engineering Program (MEP) is available to assist the academic and professional development of prospective, newly admitted, and continuing students through a variety of support services. In addition, advice on financial aid, scholarships, and employment is provided. Visit the MEP office located in room ECG 307 or call 480/965-8275, or access the Web site at www.eas.asu.edu/~omep.

Women in Applied Sciences and Engineering Program. The Women in Applied Sciences and Engineering (WISE) Program hosts seminars and workshops, and provides outreach programs to high school and community college students. WISE offers a professional development course, STE 194 Engineering for Undecided, to acquaint students with a variety of technical careers. The WISE Center, located in room ECG 214, is open for study groups, tutoring, and informal discussions. The phone number is 480/965-6882. The Web address is www.eas.asu.edu/~wise.

Student Academic Services. The dean's office of the College of Engineering and Applied Sciences maintains a special office staffed to assist students in various matters. This office coordinates the work of the College Admissions and Standards Committee and administers the probation, disqualification, and readmission processes for students who are academically deficient.

Academic Honors. Students completing baccalaureate degree requirements receive the appropriate honors designations on their diplomas consistent with the requirements specified by the university.

Students in the College of Engineering and Applied Sciences are encouraged to seek information concerning entry into those honor societies for which they may qualify. Membership in such organizations enhances the student's professional stature. The following honor societies are active within the college:

Alpha Pi Mu—Industrial Engineering Honor Society
 Chi Epsilon—Civil Engineering Honor Society
 Eta Kappa Nu—Electrical Engineering Honor Society
 Pi Tau Sigma—Mechanical Engineering Honor Society
 Sigma Gamma Tau—Aerospace Engineering Honor Society
 Sigma Lambda Chi—Construction Honor Society
 Tau Beta Pi—National Engineering Honor Society
 Upsilon Pi Epsilon—National Computer Science Honor Society

Information on any of these organizations may be obtained from the respective department or school offices.

University Honors College. The College of Engineering and Applied Sciences participates in the programs of the University Honors College, which provides enhanced educational experiences to academically superior undergraduate students. Participating students can major in any academic program. A description of the requirements and the opportunities offered by the University Honors College can be found in the "University Honors College" section, page 316.

Scholarships. Information and applications for academic scholarships for continuing students may be obtained by contacting the college's Student Academic Services or the various department or school offices. Other scholarships may be available through the university Student Financial Assistance Office.

ASU 3+2 Programs. Students desiring to earn a baccalaureate degree from Grand Canyon University (Phoenix, Arizona) in Mathematics, Chemistry, Construction, or Physics or from Southwestern University (Georgetown, Texas) in Physical Science and a baccalaureate degree in one of the engineering majors or the Construction major from ASU can take advantage of a 3+2 program approved by these institutions. Such students complete the first three years of study at their respective college or university and the last two years of study at ASU. At the end of the fourth or fifth year, assuming all degree requirements have been met, the baccalaureate degree is awarded by the student's respective college or university and the appropriate engineering or construction baccalaureate degree is awarded by ASU.

A similar 3+2 program is available to qualified students from Long Island University/C.W. Post Campus, College of Arts and Sciences, who wish to earn both a B.S. degree from C.W. Post in Mathematics or Physics and a Bachelor of Science in Engineering degree from ASU in Civil, Chemical, Electrical, Industrial, or Mechanical Engineering.

More information can be obtained by writing to one of the following offices:

OFFICE OF THE ADMINISTRATIVE VICE PRESIDENT
GRAND CANYON UNIVERSITY
3300 W CAMELBACK RD
PHOENIX AZ 85017-1097

PROVOST AND DEAN OF THE BROWN COLLEGE
OF ARTS AND SCIENCES
SOUTHWESTERN UNIVERSITY
GEORGETOWN TX 78626

DEAN, COLLEGE OF ARTS AND SCIENCES
C.W. POST CAMPUS
LONG ISLAND UNIVERSITY
BROOKVILLE NY 11548

OFFICE OF THE DEAN
COLLEGE OF ENGINEERING AND
APPLIED SCIENCES
ARIZONA STATE UNIVERSITY
PO BOX 875506
TEMPE AZ 85287-5506

ROTC Students. Students pursuing a commission through either the Air Force or Army ROTC programs are required to take from 12 to 20 hours in the Department of Aerospace Studies or Department of Military Science. To preclude excessive overloads, these students should plan on at least one additional semester to complete degree requirements. Because of accreditation requirements, aerospace studies (AES) or military science (MIS) courses are not acceptable for degree credit in engineering as social and behavioral science or humanities and fine arts under General Studies. ROTC students must also meet all other degree requirements of this college.

GENERAL INFORMATION

Definition of Terms. The terms used in this college to describe offerings are defined below for purposes of clarity.

Program of Study. This broad term describes the complete array of courses included in the study leading to a degree.

Major. This term describes a specialized group of courses contained within the program of study. Example: program of study—engineering; major—Civil Engineering.

Area of Emphasis (Technical Electives), Option, or Concentration. Each of these terms describes a selection of courses within a major or among one or more majors. The number of technical electives varies from curriculum to curriculum. In a number of the majors, the technical electives must be chosen from preselected groups. For this reason the choice of specific technical electives for an area of emphasis should be done with the advice and counsel of an advisor. Example: major—Mechanical Engineering; area of emphasis—thermosciences.

Del E. Webb School of Construction

William W. Badger
Director
(SCOB 268) 480/965-3615
www.eas.asu.edu/~dewsc

PROFESSORS

BADGER, MULLIGAN

ASSOCIATE PROFESSORS

BASHFORD, ERNZEN, KASHIWAGI, WEBER

ASSISTANT PROFESSORS

CHASEY, WALSH, WIEZEL

VISITING EMINENT SCHOLAR

SCHEXNAYDER

PURPOSE

Construction careers are so broadly diversified that no single curriculum prepares the student for universal entry into all fields. As an example, heavy construction contractors usually place more emphasis on technical and engineering science skills than do residential contractors/developers, who usually prefer a greater depth of knowledge in management and construction. To ensure a balanced understanding of the technical, professional, and philosophical standards that distinguish modern-day constructors, advisory groups representing leading associations of contractors and builders provide counsel in curriculum development. Construction has a common core of engineering science, management, and behavioral courses on which students may build defined options to suit individual backgrounds, aptitudes, and objectives. These options are not absolute but generally match major divisions of the construction industry.

DEGREES

Bachelor of Science (B.S.) Degree. The faculty in the Del E. Webb School of Construction offer the B.S. degree in Construction. Four options are available: general building construction, heavy construction, residential construction, and specialty construction.

Each option is arranged to accent requisite technical skills and to develop management, leadership, and competitive qualities in the student. Prescribed are a combination of General Studies, technical courses basic to engineering and construction, and a broad range of applied management subjects fundamental to the business of construction contracting.

Master of Science (M.S.) Degree. The faculty in the Del E. Webb School of Construction also offer the M.S. degree in Construction. Additional details for this degree are found in the *Graduate Catalog*.

Professional Accreditation and Affiliations. The Del E. Webb School of Construction is a member of the Associated Schools of Construction, an organization dedicated to the development and advancement of construction education.

The construction program is accredited by the American Council for Construction Education (ACCE).

SPECIAL PROGRAMS

The Del E. Webb School of Construction maintains a cooperative agreement with community colleges within Arizona and also with selected out-of-state colleges and universities to structure courses that are directly transferable into the construction program at ASU.

ASU 3+2 Program. The Del E. Webb School of Construction also participates in the ASU 3+2 program with Grand Canyon University and Southwestern University. See “ASU 3+2 Programs,” page 201, for details.

Student Organizations. The school has a chapter of Sigma Lambda Chi (SLC), a national honor society that recognizes high academic achievement in accepted construction programs. The school is also host to the Associated General Contractors of America (AGC) student chapter, the National Association of Home Builders (NAHB) student chapter, the National Association of Women in Construction (NAWIC) student chapter, and the Construction Women’s Alliance (CWA).

Scholarships. Apart from those given by the university, a number of scholarships from the construction industry are awarded to students registered in the construction program. The scholarships are awarded on the basis of academic achievement and participation in activities of the construction program.

ADMISSION

For information regarding requirements for admission, transfer, retention, qualification, and reinstatement, see “Undergraduate Admission,” page 60; “Admission,” page 196; and “College Degree Requirements,” page 199. A preprofessional category is available for applicants deficient in regular admission requirements. Vocational and craft-oriented courses taught at the community colleges are not accepted for credit toward a bachelor’s degree in Construction.

BASIC REQUIREMENTS

Students complete the following basic requirements before registering for advanced courses: (1) all first-semester, first-year courses and the university First-Year Composition requirement (see “University Graduation Requirements,” page 81) must be completed by the time the student has accumulated 48 semester hours of program requirements, and (2) all second-semester, first-year courses must be completed by the time the student has completed 64 semester hours of program requirements. Transfer students are given a one-semester waiver.

Any student not making satisfactory progress is permitted to register for only those courses required to correct any deficiencies.

DEGREE REQUIREMENTS

A minimum of 128 semester hours with at least 50 hours at the upper-division level is required for graduation in the general building construction, heavy construction, residential construction, and specialty construction options. Students in all options are required to complete a construction core of science-based engineering, construction, and management courses.

GRADUATION REQUIREMENTS

A student must earn a grade of “C” or higher in the mathematics and physics courses listed in the program of study.

In addition to fulfilling school and major requirements, majors must satisfy the General Studies requirements as noted in the “General Studies” section, page 85 and all university graduation requirements noted in the “University Graduations Requirements” section, page 81. Note that all three General Studies awareness areas are required. Consult your advisor for an approved list of courses.

SCHOOL COURSE REQUIREMENTS

The school requires that the General Studies requirement be satisfied in the following manner:

Humanities and Fine Arts/Social and Behavioral Sciences

CON 101 Construction and Culture: A Built Environment <i>HU, G, H</i>	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
ECN 112 Microeconomic Principles <i>SB</i>	3
HU, SB, and awareness area courses as needed	6
Total	15

Literacy and Critical Inquiry

COM 225 Public Speaking <i>L1</i>	3
CON 496 Construction Contract Administration <i>L2</i>	3
Total	6

Natural Sciences

PHY 111 General Physics <i>S1/S2</i> ¹	3
PHY 112 General Physics <i>S1/S2</i> ²	3
PHY 113 General Physics Laboratory <i>S1/S2</i> ¹	1
PHY 114 General Physics Laboratory <i>S1/S2</i> ²	1
Total	8

Numeracy

MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
STP 226 Elements of Statistics <i>N2</i>	3
Total	7
General Studies/school requirements total ³	36

¹ Both PHY 111 and 113 must be taken to secure S1 or S2 credit.
² Both PHY 112 and 114 must be taken to secure S1 or S2 credit.
³ Because of the school’s requirement for MAT 270, the total semester hours exceed the General Studies requirement of 35.

Construction Major Requirements Common to All Options (Except as Noted)

ACC 394 ST: Financial Analysis and Accounting for Small Businesses	3
or ACC 230 Uses of Accounting Information I (3)	3
CEE 310 Testing of Materials for Construction	3
CEE 340 Hydraulics and Hydrology	3

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see “General Studies,” page 85. For graduation requirements, see “University Graduation Requirements,” page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see “Classification of Courses,” page 58.

CEE 450 Soil Mechanics in Construction	3
CON 221 Applied Engineering Mechanics: Statics	3
CON 243 Heavy Construction Equipment, Methods, and Materials.....	3
CON 251 Microcomputer Applications for Construction	3
CON 252 Building Construction Methods, Materials, and Equipment.....	3
CON 273 Electrical Construction Fundamentals	3
CON 323 Strength of Materials.....	3
CON 341 Surveying	3
CON 345 Mechanical Systems.....	3
CON 371 Construction Management and Safety	3
CON 383 Construction Estimating.....	3
CON 389 Construction Cost Accounting and Control <i>N3</i>	3
CON 424 Structural Design	3
CON 453 Construction Labor Management	3
CON 455 Construction Project Management.....	3
CON 463 Foundations.....	3
CON 495 Construction Planning and Scheduling <i>N3</i>	3
ECE 100 Introduction to Engineering Design <i>N3</i>	4
LES 305 Legal, Ethical, and Regulatory Issues in Business.....	3
or LES 306 Business Law (3)	
Science elective with lab.....	4
Total common to all options	71

Advisor-approved alternates/transfer credits for these courses may vary from the total required semester hours indicated. Such variances do not reduce the minimum of 128 semester hours required for the degree.

The course work for the first two years is the same for the general building, heavy, residential, and speciality construction options.

First Semester

CON 101 Construction and Culture: A Built Environment <i>HU, G, H</i>	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry <i>IN1</i>	4
PHY 111 General Physics <i>S1/S2</i> ¹	3
PHY 113 General Physics Laboratory <i>S1/S2</i> ¹	1
Total	17

Second Semester

ECE 100 Introduction to Engineering Design <i>N3</i>	4
ECN 112 Macroeconomic Principles <i>SB</i>	3
ENG 102 First-Year Composition.....	3
PHY 112 General Physics <i>S1/S2</i> ²	3
PHY 114 General Physics Laboratory <i>S1/S2</i> ²	1
HU elective	3
Total	17

Third Semester

ACC 394 ST: Financial Analysis and Accounting for Small Businesses	3
or ACC 230 Uses of Accounting Information I (3)	
CON 243 Heavy Construction Equipment, Methods, and Materials	3
CON 251 Microcomputer Applications for Construction	3
CON 273 Electrical Construction Fundamentals	3
STP 226 Elements of Statistics <i>N2</i>	3
Total	15

Fourth Semester

COM 225 Public Speaking <i>L1</i>	3
CON 221 Applied Engineering Mechanics: Statics	3
CON 252 Building Construction Methods, Materials, and Equipment.....	3
CON 341 Surveying	3

Basic science elective with lab.....	4
Total	16

¹ Both PHY 111 and 113 must be taken to secure S1 or S2 credit.

² Both PHY 112 and 114 must be taken to secure S1 or S2 credit.

Option in General Building Construction

The general building construction option provides a foundation for students who wish to pursue careers as estimators, project managers, project engineers, and, eventually, owners of firms engaged in the construction of residential, commercial, and institutional structures. Educational focus is on building systems required for the mass development and production of large-scale projects. General building construction is addressed as an integrated process from conception through delivery of completed facilities to users.

Requirements

CON 472 Development Feasibility Reports <i>L2</i>	3
CON 483 Advanced Building Estimating	3
PUP 432 Planning and Development Control Law	3
or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes (3)	
REA 394 ST: Real Estate Fundamentals	3
Upper-division technical elective.....	3
Total	15

Option in Heavy Construction

The heavy construction option prepares students for careers related to the public works discipline. Typical projects in which they are involved are highways, railroads, airports, power plants, rapid transit systems, process plants, harbor and waterfront facilities, pipelines, dams, tunnels, bridges, canals, sewerage and water works, and mass earthwork.

Requirements

CON 344 Route Surveying.....	3
CON 486 Heavy Construction Estimating	3
Upper-division technical elective.....	9
Total	15

Option in Residential Construction

The residential construction option prepares students for careers in the residential sector of the industry. This option covers the specific methods and processes during the planning, production, marketing, and business-related activities common to residential construction.

Requirements

CON 377 Residential Construction Production Procedures.....	3
CON 477 Residential Construction Business Practices	3
MKT 300 Principles of Marketing.....	3
PUP 432 Planning and Development Control Law	3
or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes (3)	
Internship	3
Total	15

Option in Specialty Construction

The specialty construction option prepares students for careers with specialty constructors, such as mechanical and

electrical construction firms. It emphasizes the construction process at the subcontractor level.

Requirements

CON 468 Mechanical and Electrical Estimating	3
CON 494 ST: Cleanroom Construction	3
CON 494 ST: Electrical and Mechanical Project Management	3
Upper-division technical electives	6
Total	15

CONSTRUCTION (CON)

CON 101 Construction and Culture: A Built Environment. (3) F, S
An analysis of the cultural context of construction, emphasizing its centrality in the evolution and expansion of built environments as expressions of ethical and historical value systems. Lecture, speakers, field trips. *General Studies: HU, G, H.*

CON 221 Applied Engineering Mechanics: Statics. (3) F, S
Vectors, forces and moments, force systems, equilibrium, analysis of basic structures and structural components, friction, centroids, and moments of inertia. Prerequisites: MAT 270; PHY 111, 113.

CON 243 Heavy Construction Equipment, Methods, and Materials. (3) F, S
Emphasis on "Horizontal" construction. Fleet operations, maintenance programs, methods, and procedures to construct tunnels, roads, dams, and the excavation of buildings. Lab, field trips.

CON 251 Microcomputer Applications for Construction. (3) F, S
Applications of the microcomputer as a problem-solving tool for the constructor. Use of spreadsheets, information management, and multimedia software. Prerequisite: ECE 100.

CON 252 Building Construction Methods, Materials, and Equipment. (3) F, S
Emphasis on "Vertical" construction. Methods, materials, codes, and equipment used in building construction corresponding to the 16 division "Master Format." Lecture, lab.

CON 273 Electrical Construction Fundamentals. (3) F, S
Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Lecture, field trips. Prerequisites: PHY 112, 114.

CON 323 Strength of Materials. (3) F, S
Analysis of strength and rigidity of structural members in resisting applied forces. Stress, strain, shear, moment, deflections, combined stresses, connections, and moment distribution. Both US and SI units of measurement. Prerequisite: CON 221.

CON 341 Surveying. (3) F, S
Theory and field work in construction and land surveys. Lecture, lab. Prerequisite: MAT 170.

CON 344 Route Surveying. (3) S
Simple, compound, and transition curves, including reconnaissance, preliminary, and location surveys. Calculation of earthwork. Dimensional control for construction projects. Lecture, lab. Prerequisites: CON 243, 341.

CON 345 Mechanical Systems. (3) F, S
Design parameters and equipment related to heating and cooling systems for mechanical construction. Computer-aided calculations. Lecture, field trips. Prerequisites: CON 252; PHY 111, 113.

CON 371 Construction Management and Safety. (3) F, S
Organization and management theory applied to the construction process. Leadership functions. Safety procedures and equipment. OSHA requirement for construction. Prerequisite: junior standing.

CON 377 Residential Construction Production Procedures. (3) F
The process used in residential construction. How a house is built: design, permits, scheduling, codes, contracting, site management, mechanical/electrical. Prerequisite: CON 252.

CON 383 Construction Estimating. (3) F, S
Drawings and specifications. Methods and techniques used in construction estimating procedures. Introduction to computer software used in industry. Lecture, project workshops. Prerequisites: CON 243 and 251 and 252 or instructor approval.

CON 389 Construction Cost Accounting and Control. (3) F, S
Nature of construction cost. Depreciation and tax theory and variable equipment costs. Cash flow theory, investment models, profitability, and analysis. Computer applications. Funding sources and arrangements. Builder's insurance. Prerequisites: ACC 230 (or 394 ST: Financial Analysis and Accounting for Small Business); CON 251. *General Studies: N3.*

CON 424 Structural Design. (3) F, S
Economic use of concrete, steel, and wood in building and engineered structures. Design of beams, columns, concrete formwork, and connections. Lecture, field trips. Prerequisite: CEE 310.

CON 453 Construction Labor Management. (3) F, S
Labor and management history, union, and open shop organization of building and construction workers; applicable laws and government regulations; goals, economic power, jurisdictional disputes, and grievance procedures. Lecture, lab. Prerequisites: CON 371; ECN 112.

CON 455 Construction Project Management. (3) F, S
Study of methods coordinating people, equipment, materials, money, and schedule to complete a project on time and within approved cost. Lecture, class projects. Pre- or corequisite: CON 495.

CON 463 Foundations. (3) F, S
Subsurface construction theory and practice for description, excavations, exploration, foundations, pavements, and slopes. Evaluation of specifications and plans of work. Lecture, recitation, field trips. Prerequisites: CEE 450; CON 424.

CON 468 Mechanical and Electrical Estimating. (3) F
Analysis and organization of performing a cost estimate for both mechanical and electrical construction projects. Computer usage. Prerequisites: CON 273 and 345 and 383 or instructor approval.

CON 472 Development Feasibility Reports. (3) F, S
Integration of economic location theory, development cost data, market research data, and financial analysis into a feasibility report. Computer orientation. Prerequisite: REA 394 ST: Real Estate Fundamentals. *General Studies: L2.*

CON 477 Residential Construction Business Practices. (3) S
Topics addressed will include development, marketing, financing, legal issues, and sales. Prerequisite: CON 377 or instructor approval.

CON 483 Advanced Building Estimating. (3) F, S
Concepts of pricing and markup, development of historic costs, life cycle costing, change order and conceptual estimating, and emphasizing microcomputer methods. Prerequisite: CON 383.

CON 486 Heavy Construction Estimating. (3) F
Methods analysis and cost estimation for construction of highways, bridges, tunnels, dams, and other engineering works. Lecture, field trips. Prerequisites: CON 344, 383.

CON 494 ST: Special Topics. (3) F, S
(a) Cleanroom Construction
(b) Electrical and Mechanical Project Management

CON 495 Construction Planning and Scheduling. (3) F, S
Various network methods of project scheduling, such as AOA, AON Pert, bar-charting, line-of-balance, and VPM techniques. Microcomputers used for scheduling, resource allocation, and time/cost analysis. Lecture, lab. Prerequisites: CON 383; STP 226. Pre- or corequisite: CON 389. *General Studies: N3.*

CON 496 Construction Contract Administration. (3) F, S
Survey administrative procedures of general and subcontractors. Study documentation, claims, arbitration, litigation, bonding, insurance, and indemnification. Discuss ethical practices. Lecture, field trips. Prerequisites: COM 225; senior standing. *General Studies: L2.*

CON 533 Strategies of Estimating and Bidding. (3) F
Course will explore advanced concepts of the estimating process, such as modeling and statistical analysis, to improve bid accuracies. Prerequisite: CON 483 or 486 or instructor approval.

CON 540 Construction Productivity. (3) F
Productivity concepts. Data collection. Analysis of productivity data and factors affecting productivity. Means for improving production and study of productivity improvement programs. Pre- or corequisite: CON 495.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

CON 543 Construction Equipment Engineering. (3) S

Analysis of heavy construction equipment productivity using case studies. Applies engineering fundamentals to the planning, selection, and utilization of equipment. Lecture, case studies.

CON 545 Construction Project Management. (3) S

Theory and practice of construction project management. Roles of designer, owner, general contractor, and construction manager. Lecture, field trips. Pre- or corequisite: CON 495.

CON 547 Strategic Planning. (3) F

The business planning process of the construction enterprise. Differences between publicly held and closely held businesses and their exposure.

CON 561 International Construction. (3) S

An investigation of the cultural, social, economic, political, and management issues related to construction in foreign countries and remote regions.

CON 577 Construction Systems Engineering. (3) S

Models of construction operations, alternatives for structuring information flows and the control of projects, applications of information technology in construction. Prerequisite: instructor approval.

CON 589 Construction Company Financial Control. (3) F

Financial accounting and cost control at the company level in construction companies. Accounting systems. Construction project profit calculations. Financial analysis. Lecture, case studies.

School of Engineering

Daniel F. Jankowski

Director

(ECG 104) 480/965-1726

PURPOSE

A large percentage of all engineering degree holders are found in leadership positions in a wide variety of industrial settings. Although an education in engineering is generally considered to be one of the best technical educations, it also provides an opportunity for the development of many additional attributes, including ethical and professional characteristics. In this era of rapid technological change, an engineering education serves our society well as a truly liberal education. Society's needs in the decades ahead call for engineering contributions on a scale not previously experienced. The well-being of our civilization as we know it may depend upon how effectively this resource is developed.

Students studying engineering at ASU are expected to acquire a thorough understanding of the fundamentals of mathematics and the sciences and their applications to the solution of problems in the various engineering fields. The program is designed to develop a balance between science and engineering and an understanding of the economic and social consequences of engineering activity. The goals include the promotion of the general welfare of the engineering profession.

The courses offered are designed to meet the needs of the following students:

1. those who wish to pursue a career in engineering;
2. those who wish to do graduate work in engineering;
3. those who wish to have one or two years of training in mathematics, applied science, and engineering in preparation for some other technical career;

4. those who desire pre-engineering for the purpose of deciding which program to undertake or those who desire to transfer to another college or university; and
5. those who wish to take certain electives in engineering while pursuing another program in the university.

ADMISSION

See "Undergraduate Admission," page 60; "Admission," page 196; and "College Degree Requirements," page 199, for information regarding requirements for admission, transfer, retention, disqualification, and reinstatement.

Individuals who are beginning their initial college work in the School of Engineering should have completed certain secondary school units in addition to the minimum university requirements. Four units are required in mathematics. A course with trigonometry should be included. The laboratory sciences chosen must include at least one unit in physics and one unit in chemistry. Calculus, biology, and computer programming are recommended. Students who do not meet the college's subject matter requirements may be required to complete additional university course work that may not apply toward an engineering degree. One or more of the courses—CHM 113 General Chemistry, CSE 181 Applied Problem Solving with BASIC, MAT 170 Precalculus, and PHY 105 Basic Physics—may be required to satisfy omissions or deficiencies.

DEGREES

The Bachelor of Science in Engineering (B.S.E.) degree consists of three parts:

1. university requirements (e.g., General Studies, First-Year Composition);
2. an engineering core; and
3. a major.

The courses identified for each of these parts are intended to meet requirements imposed by the university and by the professional accrediting agency, Accreditation Board for Engineering and Technology, Inc. (ABET), for programs in engineering.

The B.S. degree in Computer Science consists of two parts:

1. university requirements (e.g., General Studies, First-Year Composition); and
2. a major.

The courses identified for each of these parts are intended to meet requirements imposed by the university and by the professional accrediting agency, the Computer Science Accreditation Board (CSAB), for programs in computing science.

In addition to First-Year Composition, the university requires, under the heading of General Studies, courses in literacy and critical inquiry, humanities and fine arts, social and behavioral sciences, numeracy, and natural sciences (see "General Studies," page 85). There are also requirements in historical awareness, global awareness, and cultural diversity in the United States. ABET and CSAB impose additional requirements, particularly in mathematics and the basic sciences and in the courses for the major.

The engineering core is an organized body of knowledge that serves as a foundation to engineering and for further specialized studies in a particular engineering major.

The courses included in the engineering core are taught in such a manner that they serve as basic background material: (1) for all engineering students who will be taking subsequent work in the same and related subject areas; and (2) for those students who may not desire to pursue additional studies in a particular subject area. Thus, subjects within the engineering core are taught with an integrity and quality appropriately relevant to the particular discipline but always with an attitude and concern for both engineering in general and for the particular major(s).

The majors available are of two types: (1) those associated with a particular department within the School of Engineering (for example, Electrical Engineering and Civil Engineering) and (2) those offered as options in Engineering Special Studies (for example, premedical engineering). With the exception of the Computer Science major, all curricula are extensions beyond the engineering core and cover a wide variety of subject areas within each field. Some of the credits in the major are reserved for the student's use as an area of emphasis. These credits are traditionally referred to as *technical electives*.

Majors and areas of emphasis are offered by the six departments: Chemical, Bio, and Materials Engineering; Civil and Environmental Engineering; Computer Science and Engineering; Electrical Engineering; Industrial and Management Systems Engineering; and Mechanical and Aerospace Engineering. The major in Engineering Special Studies is administered by the Office of the Dean. Engineering Special Studies makes use of the general structure of the engineering curricula noted above and provides students with an opportunity for study in engineering options not available in the traditional engineering curricula at ASU.

The first two years of study are concerned primarily with general education requirements, English proficiency, and the engineering core. The final two years of study are concerned with the engineering core and the major, with a considerable part of the time being spent on the major.

The semester-by-semester selection of courses may vary from one field to another, particularly at the upper-division level, and is determined by the student in consultation with a faculty advisor. An example of a typical full-time freshman schedule is shown below; depending on a particular student's circumstances, many other examples are possible.

Typical Freshman Year

CHM 114	General Chemistry for Engineers S1/S2	4
ECE 100	Introduction to Engineering Design N3	4
ECN 111	Macroeconomic Principles SB	3
	or ECN 112 Microeconomic Principles SB (3)	
ENG 101	First-Year Composition	3
ENG 102	First-Year Composition	3
MAT 270	Calculus with Analytic Geometry I NI	4
MAT 271	Calculus with Analytic Geometry II NI	4

PHY 121	University Physics I: Mechanics S1/S2*	3
PHY 122	University Physics Laboratory I S1/S2*	1
	HU, SB, and awareness area course	3
Total		32

* Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

Well-prepared students who have no outside commitments can usually complete the program of study leading to an undergraduate degree in engineering in four years (eight semesters at 16 semester hours per semester). Many students, however, find it advantageous or necessary to devote more than four years to the undergraduate program by pursuing, in any semester, fewer studies than are regularly prescribed. Where omissions or deficiencies exist, e.g., in chemistry, computer programming, English, mathematics, and physics, the student must complete more than the minimum of 128 semester hours. Therefore, in cases of inadequate secondary preparation, poor health, or financial necessity requiring considerable time for outside work, the undergraduate program is extended beyond four years.

DEGREE REQUIREMENTS

The degree programs in engineering at ASU are intended to develop habits of quantitative thought having equal utility for both the practice of engineering and other professional fields. In response to the opportunities provided by changing technology, educational research, and industrial input, possible improvements of various aspects of these programs are routinely considered. It is the intent of the faculty that all students be appropriately prepared in the four areas described below.

1. *Oral and written English.* Communication skills are an essential component of an engineering education. All engineering students must complete the university First-Year Composition requirement (see "University Graduation Requirements," page 81), and the literacy and critical inquiry component under "Core Areas," page 86, of the General Studies requirement, which involves two courses beyond First-Year Composition.
2. *Selected nonengineering topics.* This area ensures that the engineering student acquires a satisfactory level of basic knowledge in the humanities and fine arts, social and behavioral sciences, numeracy, and the natural sciences. Courses in these subjects give engineers an increased awareness of their social responsibilities, provide an understanding of related factors in the decision-making process, and also provide a foundation for the study of engineering. Required courses go toward fulfilling the General Studies requirement. Additional courses in mathematics and the basic sciences are selected to meet ABET requirements.
Because of accreditation requirements, aerospace studies (AES) and military science (MIS) courses are not acceptable for engineering degree credit in fulfilling the humanities and fine arts and social and behavioral science portions of the General Studies requirement.
3. *Selected engineering topics.* This area involves courses in engineering science and engineering design. The

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

courses further develop the foundation for the study of engineering and provide the base for specialized studies in a particular engineering discipline. The specific courses are included in the engineering core and in the major. While some departmental choices are allowed, all students are required to take ECE 100 Introduction to Engineering Design and ECE 300 Intermediate Engineering Design as part of the engineering core. These courses, together with other experiences in the engineering core and in the major, serve to integrate the study of design, the “process of devising a system, component, or process to meet desired needs” (ABET), throughout the engineering curricula.

4. *Specific engineering discipline.* This area provides a depth of understanding of a more definitive body of knowledge that is appropriate for a specific engineering discipline. Courses build upon the background provided by the earlier completed portions of the curriculum and include a major design experience as well as technical electives that may be selected by the student with the assistance of an advisor. The catalog material for the individual engineering majors describes specific departmental requirements.

COURSE REQUIREMENTS

A summary of the degree requirements is as follows:

First-Year Composition.....	6
General Studies/school requirements.....	58
Engineering core.....	15–19
Major (including area of emphasis)*.....	45–49
Total.....	128

* The requirements for each of the majors offered are described on the following pages.

The specific course requirements for the B.S. and B.S.E. degrees follow.

First-Year Composition

Choose among the course combinations below.....	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
-----or-----	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
-----or-----	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total.....	6

General Studies/School Requirements

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i> ¹	
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Macroeconomic Principles <i>SB</i> (3)	
HU course(s).....	6 or 10
SB course(s).....	3 or 7
Total.....	12–20

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 400 Engineering Communications <i>L2</i>	3
or approved department <i>L2</i> course (3)	
Total.....	6

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
or CHM 116 General Chemistry <i>S1/S2</i> (4)	
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ²	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ²	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ³	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ³	1
Department basic science elective.....	3
Total.....	15

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
Department mathematics elective.....	2
Total.....	21
General Studies/school requirements total.....	58

¹ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.

² Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

³ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

Engineering Core

A minimum of five of the following eight courses are required, totaling 15 to 19 semester hours. Courses selected are subject to departmental approval. See department requirements.

ECE 210 Engineering Mechanics I: Statics.....	3
ECE 301 Electrical Networks I.....	4
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 334 Electronic Devices and Instrumentation.....	4
ECE 340 Thermodynamics.....	3
or CHM 441 General Physical Chemistry (3)	
or MSE 430 Thermodynamics of Materials (3)	
ECE 350 Structure and Properties of Materials.....	3
or CHM 442 General Physical Chemistry (3)	
or ECE 351 Civil Engineering Materials (3)	
or ECE 352 Properties of Electronic Materials (4)	
Choose one microcomputer/microprocessor course below.....	3 or 4
BME 470 Microcomputer Applications in Bioengineering (4)	
CHE 461 Process Control <i>N3</i> (4)	
CSE 225 Assembly Language Programming and Microprocessors (Motorola) (4)	
or EEE 225 Assembly Language Programming and Microprocessors (Motorola) (4)	
CSE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
or EEE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
IEE 463 Computer-Aided Manufacturing and Control <i>N3</i> (3)	
Engineering core minimum total.....	15

GRADUATION REQUIREMENTS

To qualify for graduation from the School of Engineering, a student must have a minimum cumulative GPA of 2.00 in addition to having a GPA of at least 2.00 for the courses in the major field.

PROFESSIONAL ACCREDITATION

The undergraduate programs in Aerospace Engineering, Bioengineering, Chemical Engineering, Civil Engineering, Computer Systems Engineering, Electrical Engineering, Industrial Engineering, Materials Science and Engineering, and Mechanical Engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, 410/347-7700. The Bachelor of Science program in Computer Science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB).

ANALYSIS AND SYSTEMS (ASE)

ASE 100 College Adjustment and Survival. (2) F, S
Exploration of career goals and majors. Emphasis on organization and development of study skills, including time management, stress management, and use of the library.

ASE 194 ST: Special Topics. (2) F
(a) MEP Academic Success

ASE 399 Cooperative Work Experience. (1) F, S, SS
Usually involves two six-month work periods with industrial firms or government agencies alternated with full-time semester and summer sessions studies. Not open to students from other colleges on campus. May be repeated for credit. Prerequisites: at least 45 hours completed in major area with minimum 2.50 GPA; instructor approval.

ASE 485 Engineering Statistics. (3) F, S, SS
Designing statistical studies for solutions to engineering problems. Methods include regression, design and analysis of experiments, and other statistical topics. Prerequisite: ECE 380. *General Studies: N2.*

ASE 490 Project in Design and Development. (2–3) F, S, SS
Individual project in creative design and synthesis. Course may be repeated. Prerequisite: senior standing.

ASE 496 Professional Seminar. (0) F, S
Topics of interest to students in the engineering special and interdisciplinary studies.

ASE 500 Research Methods: Engineering Statistics. (3) F, S, SS
Designing statistical studies for solutions to engineering problems. Methods include regression, design and analysis of experiments, and other statistical topics. Prerequisite: ECE 380.

ASE 582 Linear Algebra in Engineering. (3) F
Development and solution of systems of linear algebraic equations. Applications from mechanical, structural, and electrical fields of engineering. Prerequisite: MAT 242 or equivalent.

ASE 586 Partial Differential Equations in Engineering. (3) S
Development and solution of partial differential equations in engineering. Applications in solid mechanics, vibrations, and heat transfer. Prerequisites: ECE 386; MAT 242, 274.

ENGINEERING CORE (ECE)

ECE 100 Introduction to Engineering Design. (4) F, S
Introduction to engineering design philosophy and methodology: computer modeling of systems, processes, and components; design for customer satisfaction, profitability, quality and manufacturing; economic analysis; flow charting; sketching CAD; and teaming. A term design project is included. Prerequisites: high school computing and physics and algebra courses or equivalents. *General Studies: N3.*

ECE 194 ST: Special Topics. (2) F, S
(a) Introduction to Engineering Design I. (2) F
(b) Introduction to Engineering Design II. (2) S

ECE 210 Engineering Mechanics I: Statics. (3) F, S, SS
Force systems, resultants, equilibrium, distributed forces, area moments, fluid statics, internal stresses, friction, energy criterion for equilibrium, and stability. Lecture, recitation. Prerequisites: ECE 100; MAT 271 (or 291); PHY 121, 122.

ECE 300 Intermediate Engineering Design. (3) F, S, SS
Engineering design process concentrating on increasing the student's ability to prepare well-written technical communication and to define problems and generate and evaluate ideas. Teaming skills enhanced. Prerequisites: ECE 100; ENG 102 (or 105 or 108); at least two other engineering core courses. *General Studies: L1.*

ECE 301 Electrical Networks I. (4) F, S, SS
Introduction to electrical networks. Component models, transient, and steady-state analysis. Lecture, lab. Prerequisite: ECE 100. Pre- or corequisites: MAT 274; PHY 131, 132.

ECE 312 Engineering Mechanics II: Dynamics. (3) F, S, SS
Kinematics and kinetics of particles, translating and rotating coordinate systems, rigid body kinematics, dynamics of systems of particles and rigid bodies, and energy and momentum principles. Lecture, recitation. Prerequisites: ECE 210; MAT 274.

ECE 313 Introduction to Deformable Solids. (3) F, S, SS
Equilibrium, strain-displacement relations, and stress-strain-temperature relations. Applications to force transmission and deformations in axial, torsional, and bending of bars. Combined loadings. Lecture, recitation. Prerequisites: ECE 210; MAT 274.

ECE 314 Engineering Mechanics. (4) F, S, SS
Force systems, resultants, moments and equilibrium. Kinematics and kinetics of particles, systems of particles and rigid bodies. Energy and momentum principles. Lecture, recitation. Prerequisites: ECE 100; MAT 274; PHY 121, 122.

ECE 334 Electronic Devices and Instrumentation. (4) F, S, SS
Application of electric network theory to semiconductor circuits. Diodes/transistors/amplifiers/opamps/digital logic gates, and electronic instruments. Lecture, lab. Prerequisite: ECE 301.

ECE 340 Thermodynamics. (3) F, S, SS
Work, heat, and energy transformations and relationships between properties; laws, concepts, and modes of analysis common to all applications of thermodynamics in engineering. Lecture, recitation. Prerequisites: CHM 114 (or 116); ECE 210; PHY 131. Pre- or corequisite: MAT 274.

ECE 350 Structure and Properties of Materials. (3) F, S, SS
Basic concepts of material structure and its relation to properties. Application to engineering problems. Prerequisites: CHM 114 (or 116); PHY 121.

ECE 351 Civil Engineering Materials. (3) F, S
Structure and behavior of civil engineering materials. Laboratory investigations and test criteria. Lecture, lab. Prerequisite: ECE 313.

ECE 352 Properties of Electronic Materials. (4) F, S, SS
Schrodinger's wave equation, potential barrier problems, bonds of crystals, the band theory of solids, semiconductors, superconductor dielectric, and magnetic properties. Prerequisites: CHM 114 (or 116); MAT 274; PHY 241.

ECE 380 Probability and Statistics for Engineering Problem Solving. (3) F, S
Applications oriented course with computer-based experience using statistical software for formulating and solving engineering problems. 2 hours lecture, 2 hours lab. Prerequisite: MAT 271. *General Studies: N2.*

ECE 384 Numerical Analysis for Engineers I. (2) F, S
Numerical solution of algebraic and transcendental equations and systems of linear equations. Numerical integration. Curve fitting. Error bounds and error propagation. Emphasis on use of digital computer. Prerequisite: MAT 272 or 291.

ECE 385 Numerical Analysis for Engineers II. (2) S
Continuation of ECE 384. Numerical solution of partial differential equations and mixed equation systems. Introduction to experimental design and optimization techniques. Prerequisite: ECE 384.

ECE 386 Partial Differential Equations for Engineers. (2) F, S
Boundary value problems, separation of variables, and Fourier series as applied to initial-boundary value problems. Prerequisite: MAT 274.

ECE 394 ST: Special Topics. (3–4) F, S
(a) Conservation Principles. (4) F, S
(b) Engineering Systems. (4) F, S
(c) Introduction to Manufacturing Engineering. (3) F, S
(d) Properties that Matter. (4) F, S

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

ECE 400 Engineering Communications. (3) F, S, SS

Planning and preparing engineering publications and oral presentations, based on directed library research related to current engineering topics. Prerequisites: ENG 102 (or 105 or 108); completion of General Studies L1 requirement (or ECE 300); senior standing in an engineering major. *General Studies: L2.*

SOCIETY, VALUES, AND TECHNOLOGY (STE)**STE 194 ST: Special Topics.** (2) F

(a) Engineering for Undecided

STE 201 Introduction to Bioengineering. (3) F

Impact of bioengineering on society. Developing an awareness of the contributions of bioengineering to solve medical and biological problems. Cross-listed as BME 201. Credit is allowed for only BME 201 or STE 201. Prerequisite: ENG 102 or 105 or 108. *General Studies: L1.*

STE 208 Patterns in Nature. (4) F, S

Project-oriented science course with computer training to develop critical thinking, and technical skills for student-oriented science lessons K-12. Lecture, lab. Cross-listed as PHS 208. Credit is allowed for only PHS 208 or STE 208. Prerequisite: college-level science course or instructor approval. *General Studies: S1/S2.*

Department of Chemical, Bio, and Materials Engineering

Eric J. Guilbeau
Chair

(ECG 202) 480/965-3313

www.eas.asu.edu/~cbme

The faculty in the Department of Chemical, Bio, and Materials Engineering offer the B.S. degree in three exciting disciplines: chemical engineering, bioengineering, and materials science and engineering. Each of these majors builds on a broad base of knowledge within the basic and mathematical sciences and the engineering core. Each offers excellent career opportunities.

Chemical engineers design and operate processes that may include chemical change. They combine the science of chemistry with the discipline of engineering in order to solve complex problems in a wide variety of industries. Challenging job opportunities exist not only in the chemical and petroleum industries, but also in the plastics, electronics, computer, metals, space, food, drug, and health care industries. In these industries, chemical engineers practice in a wide variety of occupations including environmental control, surface treatments, energy and materials transformation, biomedical applications, fermentation, protein recovery, extractive metallurgy, and separations. In the environmental area, chemical engineers develop methods to reduce the pollution created in manufacturing processes, devise techniques to recover usable materials from wastes, design waste storage and treatment facilities, and design pollution control strategies.

Bioengineering (synonyms: biomedical engineering or medical engineering) is the discipline of engineering that applies principles and methods from engineering, the life sciences, and the medical sciences to understand, define, and solve problems in medicine, physiology, and biology. Bioengineering students typically pursue either a career in the medical-device/biotechnology industry or a career in bioengineering, medical or biotechnology research or enter

a postgraduate program in clinical or veterinary medicine or dentistry. The practicing bioengineer uses engineering principles and technology to develop instrumentation, biomaterials, diagnostic and therapeutic devices, artificial organs, and other equipment needed in medicine and biology. They also discover new fundamental principles regarding the functioning and structure of living systems.

Materials science and engineering uses fundamental knowledge in chemistry and physics to correlate relationships between the structure and processing of materials and their properties. Students educated in this discipline decide how to optimize existing materials or how to develop new advanced materials and processing techniques. Students who major in materials science and engineering will find employment opportunities in a variety of industries and research facilities which include aerospace, electronics, energy conversion, manufacturing, medical devices, semiconductors, and transportation.

The following sections describe the curriculum requirements for the Bachelor of Science in Engineering degree in each of these disciplines. Faculty within the department also participate in the Engineering Special Studies program in premedical engineering which is described separately in the "Programs in Engineering Special Studies" section, page 251.

CHEMICAL ENGINEERING—B.S.E.

PROFESSORS

BERMAN, GUILBEAU, RAUPP, SATER

ASSOCIATE PROFESSORS

BECKMAN, BELLAMY, BURROWS, GARCIA,
RIVERA, TORREST

ASSISTANT PROFESSOR

S. BEAUDOIN

LECTURER

D. BEAUDOIN

Chemical engineers are generally concerned with transfer within and between liquid, gas, and solid phases and the chemical changes that may also occur. They design and operate processes that accommodate such changes, including the chemical activation of materials. Typically this involves complex multicomponent systems wherein the interactions between species have to be considered and analyzed. The new challenge in chemical engineering is to apply the principles of fluid dynamics, mass transfer, solution thermodynamics, reaction kinetics, and separation techniques to technological endeavors such as pollution control within manufacturing and the environment, integrated circuit design, solid-state surface treatments, and materials processing.

Consequently, in addition to the chemical and petroleum industries, chemical engineers find challenging opportunities in the plastics, solid-state, electronics, computer, metals, space, food, drug, and health care industries; where they practice in a wide variety of occupations, such as environmental control, surface treatments, energy and materials transformations, biomedical applications, fermentation, protein recovery, extractive metallurgy, and separations. While

a large percentage of the industrial positions are filled by graduates with bachelor's degrees, there are lucrative and creative opportunities in research and development for those who acquire postgraduate education.

Subspecializations have developed within the profession. However, the same broad body of knowledge is generally expected of all chemical engineers for maximum flexibility in industrial positions. The preparation for chemical engineering is accomplished by a blend of classroom instruction and laboratory experience.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Chemical Engineering. A minimum of 50 upper-division semester hours is required.

The course work for the undergraduate degree can be classified into the following categories (in semester hours):

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
— or —	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
— or —	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
HU, SB, and awareness area courses ¹	13
Total	16

Literacy and Critical Inquiry

CHE 352 Transport Laboratories <i>L2</i>	3
ECE 300 Intermediate Engineering Design <i>L1</i>	3
Total	6

Natural Sciences/Basic Sciences

CHM 113 General Chemistry <i>S1/S2</i>	4
CHM 116 General Chemistry <i>S1/S2</i>	4
CHM 331 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory	1
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ²	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ²	1
Total	16

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
ECE 384 Numerical Analysis for Engineers I	2
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
Total	21
General Studies/school requirements total	59

Engineering Core

CHE 342 Applied Chemical Thermodynamics	4
CHE 461 Process Control <i>N3</i>	4

ECE 394 ST: Conservation Principles	4
ECE 394 ST: Engineering Systems	4
ECE 394 ST: Properties that Matter	4
Total	20

Major

CHE 311 Introduction to Chemical Processing	3
CHE 331 Transport Phenomena I: Fluids	3
CHE 332 Transport Phenomena II: Energy Transfer	3
CHE 333 Transport Phenomena III: Mass Transfer	3
CHE 432 Principles of Chemical Engineering Design	3
CHE 442 Chemical Reactor Design	3
CHE 451 Chemical Engineering Laboratory	2
CHE 462 Process Design	3
CHM 332 General Organic Chemistry	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
ECE 385 Numerical Analysis for Engineers II	2
Technical electives	12
Total	43

¹ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.

² Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

Consult with your department academic advisor to ensure that all requirements are met.

The technical elective courses must be selected from upper-division courses with an advisor's approval and must include two three-semester-hour chemistry courses; a three-semester-hour natural science or materials course; and a three-semester-hour chemical engineering course.

To fulfill accreditation requirements and to prepare adequately for the advanced chemistry courses, Chemical Engineering majors are required to take the CHM 113 and 116 introductory chemistry sequence (CHM 117 and 118 are acceptable substitutes). Other freshman chemistry courses are *not acceptable*, and transfer students who have taken another chemistry course may be required to enroll in CHM 113 and 116.

The faculty in the Department of Chemical, Bio, and Materials Engineering also offer graduate programs leading to the M.S.E., M.S., and Ph.D. degrees. These programs provide a blend of classroom instruction and research. A wide variety of topical and relevant research projects are available for thesis topics. Students interested in these programs should contact the department for up-to-date descriptive literature.

Chemical Engineering Areas of Emphasis

Students who wish to specialize may develop an area of interest through the use of technical electives and selective substitutions for required courses. Substitutions must be approved by the advisor and the Department Standards Committee and must be consistent with ABET accreditation criteria. No substitution of CHE 462 is allowed. The following are possible elective areas of emphasis with suggested courses. A student may choose electives within the general department guidelines and does not have to select one of the areas listed.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

Biochemical. Students wishing to prepare for a career in biotechnology, fermentation, food processing, pharmaceuticals, and other areas within biochemical engineering should select from the following:

Chemistry Electives

CHM 361 Principles of Biochemistry.....	3
CHM 461 General Biochemistry	3
CHM 462 General Biochemistry	3

Technical Electives

AGB 440 Food Safety	3
AGB 441 Food Chemistry.....	4
AGB 442 Food and Industrial Microbiology	3
AGB 443 Food and Industrial Fermentations	4
CHE 475 Biochemical Engineering.....	3
CHE 476 Bioreaction Engineering	3
CHE 477 Bioseparation Processes.....	3

Biomedical. Students who are interested in biomedical engineering but wish to maintain a strong, broad chemical engineering base should select from the following:

Chemistry Electives

CHM 361 Principles of Biochemistry.....	3
CHM 461 General Biochemistry	3
CHM 462 General Biochemistry	3

Technical Electives

BME 318 Biomaterials.....	3
BME 411 Biomedical Engineering I.....	3
BME 412 Biomedical Engineering II.....	3
BME 413 Biomedical Instrumentation L2.....	3
BME 435 Physiology for Engineers.....	4

Environmental. ASU does not offer a B.S.E. degree in Environmental Engineering, but students with this interest are encouraged to pursue a B.S.E. degree in Chemical Engineering with this area of emphasis. Students interested in the management of hazardous wastes and air and water pollution should select from the following:

Chemistry Electives

CHM 302 Environmental Chemistry	3
CHM 361 Principles of Biochemistry.....	3
CHM 461 General Biochemistry	3
CHM 481 Geochemistry	3

Technical Electives

CEE 361 Introduction to Environmental Engineering	4
CEE 362 Unit Operations in Environmental Engineering.....	3
CEE 561 Physical-Chemical Treatment of Water and Waste	3
CEE 563 Environmental Chemistry Laboratory	3
CHE 474 Chemical Engineering Design for the Environment.....	3
CHE 478 Industrial Water Quality Engineering	3
CHE 479 Air Quality Control	3
CHE 533 Transport Processes I.....	3

Materials. Students interested in the development and production of new materials such as alloys, ceramics, composites, polymers, semiconductors, and superconductors should select from the following:

Chemistry Electives

CHM 441 General Physical Chemistry.....	3
CHM 442 General Physical Chemistry.....	3
CHM 453 Inorganic Chemistry.....	3
CHM 471 Solid-State Chemistry	3

Technical Electives

BME 318 Biomaterials.....	3
CHE 458 Semiconductor Material Processing	3
ECE 352 Properties of Electronic Materials	4

MSE 353 Introduction to Materials Processing and Synthesis	3
MSE 354 Experiments in Materials Synthesis and Processing I ...	2
MSE 431 Corrosion and Corrosion Control.....	3
MSE 453 Experiments in Materials Synthesis and Processing II.....	2
MSE 454 Advanced Materials Processing and Synthesis.....	3
MSE 470 Polymers and Composites.....	3

Premedical. Students planning to attend medical school should select courses from those listed under the biomedical emphasis. In addition, BIO 181, 182, and CHM 336 must be taken to satisfy medical-school requirements but are not counted toward the Chemical Engineering bachelor's degree.

Process Engineering. The engineering core and required chemical engineering courses serve as a suitable background for students intending to enter the traditional petrochemical and chemical process industries. Students can build on this background by selecting courses with the approval of their advisor. Examples of these courses are as follows:

Energy Conversion and Conservation

CHE 528 Process Optimization Techniques	3
CHE 554 New Energy Technology	3
CHE 556 Separation Processes.....	3
MAE 436 Combustion	3

Plant Administration and Management

CHE 479 Air Quality Control.....	3
CHE 528 Process Optimization Techniques	3
IEE 300 Economic Analysis for Engineers.....	3
IEE 431 Engineering Administration.....	3

Simulation, Control, and Design

CHE 494 ST: Special Topics.....	1-4
CHE 527 Advanced Applied Mathematical Analysis in Chemical Engineering.....	3
CHE 528 Process Optimization Techniques	3
CHE 556 Separation Processes.....	3
CHE 563 Chemical Engineering Design	3

Semiconductor Processing. Students who are interested in the development and manufacturing of semiconductor and other electronic devices should select from the following:

Chemistry Elective

CHM 441 General Physical Chemistry.....	3
CHM 442 General Physical Chemistry.....	3
CHM 453 Inorganic Chemistry.....	3
CHM 471 Solid-State Chemistry	3

Technical Electives

CHE 458 Semiconductor Material Processing	3
CHE 494 ST: Special Topics.....	1-4
ECE 352 Properties of Electronic Materials	4
EEE 435 Microelectronics	3
EEE 436 Fundamentals of Solid-State Devices	3
EEE 439 Semiconductor Facilities and Cleanroom Practices.....	3
MSE 353 Introduction to Materials Processing and Synthesis	3
MSE 354 Experiments in Materials Synthesis and Processing I ...	2
MSE 453 Experiments in Materials Synthesis and Processing II.....	2
MSE 454 Advanced Materials Processing and Synthesis.....	3
MSE 472 Integrated Circuit Materials Science.....	3

**Chemical Engineering
Program of Study
Typical Four-Year Sequence**

First Year

First Semester

CHM 113 General Chemistry <i>SI/S2</i>	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>	4
Total	15

Second Semester

CHM 116 General Chemistry <i>SI/S2</i>	4
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II	4
PHY 121 University Physics I: Mechanics <i>SI/S2*</i>	3
PHY 122 University Physics Laboratory I <i>SI/S2*</i>	1
Total	15

Second Year

First Semester

CHE 311 Introduction to Chemical Processing	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
ECE 394 ST: Conservation Principles	4
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Macroeconomic Principles <i>SB</i> (3)	
MAT 274 Elementary Differential Equations <i>NI</i>	3
Total	16

Second Semester

CHE 331 Transport Phenomena I: Fluids	3
ECE 384 Numerical Analysis for Engineers I	2
ECE 394 ST: Properties that Matter	4
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
HU or SB elective	4
Total	17

Third Year

First Semester

CHE 332 Transport Phenomena II: Energy Transfer	3
CHE 342 Applied Chemical Thermodynamics	4
CHM 331 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory	1
ECE 300 Intermediate Engineering Design <i>L1</i>	3
HU or SB elective	3
Total	17

Second Semester

CHE 333 Transport Phenomena III: Mass Transfer	3
CHE 352 Transport Laboratories <i>L2</i>	3
CHE 432 Principles of Chemical Engineering Design	3
CHM 332 General Organic Chemistry	3
ECE 385 Numerical Analysis for Engineers II	2
ECE 394 ST: Engineering Systems	4
Total	18

Fourth Year

First Semester

CHE 442 Chemical Reactor Design	3
CHE 451 Chemical Engineering Laboratory	2
CHE 461 Process Control <i>N3</i>	4
HU, SB, and awareness area courses	3

Technical elective	3
Total	15

Second Semester

CHE 462 Process Design	3
HU, SB, and awareness area courses	3
Technical elective	9
Total	15
Total degree requirements:	128

* Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

BIOENGINEERING—B.S.E.

PROFESSORS

GUILBEAU, TOWE

ASSOCIATE PROFESSORS

GARCIA, HE, KIPKE, MASSIA, PIZZICONI, SWEENEY,
YAMAGUCHI

ASSISTANT PROFESSOR

PANITCH

LECTURER

D. BEAUDOIN

Bioengineering (synonyms: biomedical engineering, medical engineering) is the discipline of engineering that applies principles and methods from engineering, the physical sciences, the life sciences, and the medical sciences to understand, define, and solve problems in medicine, physiology, and biology. Bioengineering bridges the engineering, physical, life, and medical sciences. More specifically, the bioengineering program at ASU educates engineering students to use engineering principles and technology to develop instrumentation, materials, diagnostic and therapeutic devices, artificial organs, and other equipment needed in medicine and biology and to discover new fundamental principles regarding the functioning and structure of living systems. The multidisciplinary approach to solving problems in medicine and biology has evolved from exchanges of information between specialists in the concerned areas.

Because a depth of knowledge from at least two diverse disciplines is required in the practice of bioengineering, students desiring a career in bioengineering should plan for advanced study beyond the bachelor's degree. The Bioengineering major at ASU is especially designed for students desiring graduate study in bioengineering, a career in the medical-device/biotechnology industry, a career in biomedical research, a career in biotechnology research, or entry into a medical college.

Graduate degree programs in Bioengineering are offered at ASU at both the master's and doctoral levels. For more information concerning these degree programs, consult the *Graduate Catalog*.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. in Bioengineering degree. A minimum of 50 upper-division semester hours is required.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 81.

COURSE REQUIREMENTS

The course work, in semester hours, for the undergraduate degree can be classified into the following categories:

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
-----or-----	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
-----or-----	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
HU, SB, and awareness area courses	13
Total	16

Literacy and Critical Inquiry

BME 413 Biomedical Instrumentation <i>L2</i>	3
BME 423 Biomedical Instrumentation Laboratory <i>L2</i>	1
ECE 300 Intermediate Engineering Design <i>L1</i>	3
Total	7

Natural Sciences/Basic Sciences

CHM 113 General Chemistry <i>S1/S2</i>	4
CHM 116 General Chemistry <i>S1/S2</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
Total	16

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
MAT 242 Elementary Linear Algebra	2
or ECE 384 Numerical Analysis for Engineers I (2)	
or ECE 386 Partial Differential Equations for Engineers I (2)	
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
Total	21
General Studies/school requirements total	60

Engineering Core

ECE 210 Engineering Mechanics I: Statics	3
ECE 301 Electrical Networks I	4
ECE 334 Electronic Devices and Instrumentation	4
ECE 340 Thermodynamics	3

ECE 350 Structure and Properties of Materials	3
Total	17

Major

BIO 181 General Biology <i>S1/S2</i>	4
BME 201 Introduction to Bioengineering <i>L1</i>	3
BME 318 Biomaterials	3
BME 331 Biomedical Engineering Transport I: Fluids	3
BME 334 Bioengineering Heat and Mass Transfer	3
BME 416 Biomechanics	3
BME 417 Biomedical Engineering Capstone Design I	3
BME 435 Physiology for Engineers	4
BME 470 Microcomputer Applications in Bioengineering	4
BME 490 Biomedical Engineering Capstone Design II	1-5
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
Technical electives	9
Minimum total	45

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

The major BME courses require a grade of "C" or higher to advance in the program and to receive a baccalaureate degree.

Bioengineering Areas of Emphasis

Students interested in a career in bioengineering may elect to emphasize either biochemical, bioelectrical, biomaterials engineering, biomechanical, bionuclear, biosystems, molecular and cellular bioengineering, or pre-medical engineering.

Biochemical Engineering. This emphasis is designed to strengthen the student's knowledge of chemistry and transport phenomena and is particularly well suited for students interested in biotechnology. Technical electives must include: CHM 331, 332, and 361.

Bioelectrical Engineering. This emphasis is designed to strengthen the student's knowledge of electrical systems, electronics, and signal processing. Students considering a career in bioelectrical phenomena, biocontrol systems, medical instrumentation, noninvasive imaging, neural engineering, and electrophysiology should consider this area of emphasis. Technical electives must include the following:

BME 350 Signals and Systems for Bioengineers	3
or EEE 303 Signals and Systems (3)	
BME 419 Biocontrol Systems	3
EEE 302 Electrical Networks II	3
Total	9

Biomaterials Engineering. This area of emphasis integrates the student's knowledge of materials science and engineering with biomaterials science and engineering concepts for the design of materials intended to be used for the development of medical and diagnostic devices. It emphasizes structure-property relationships of engineering materials (metals, polymers, ceramics, and composites) and biological materials, biomaterial-host response phenomena, technical and regulatory aspects of biomaterials testing and evaluation. Students interested in careers in the biomaterials, medical device, or biotechnology industries should con-

sider this area of emphasis. Technical electives must include the following:

MSE 353 Introduction to Materials Processing and Synthesis.....	3
MSE 355 Introduction to Materials Science and Engineering.....	3
MSE 470 Polymers and Composites.....	3
or MSE 471 Introduction to Ceramics (3)	—
Total	9

Biomechanical Engineering. This emphasis is designed to strengthen the student's knowledge of mechanics and control theory. Students interested in careers related to biomechanical design, orthotic/prosthetic devices, rehabilitation engineering, and orthopedic implants should consider this area of emphasis. It also provides the fundamentals for the study of neuromuscular control and the study of human motion. The following course is a required selection in the engineering school requirements (page 199):

ECE 384 Numerical Analysis for Engineers I2
or MAT 242 Elementary Linear Algebra (2)

Technical electives must include the following:

BME 350 Signals and Systems for Bioengineers.....	3
or BME 419 Biocontrol Systems (3)	—
or EEE 303 Signals and Systems (3)	—
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
Total	9

Biomedical Imaging Engineering. This emphasis is designed to strengthen the student's knowledge of radiation interactions, health physics, medical diagnostic imaging (MRI, PET, X-ray, CT), radiation protection, and nuclear instrumentation. Students considering careers in medical engineering or health physics should consider this area of emphasis. Technical electives include the following:

PHY 361 Introductory Modern Physics.....	3
Department-approved electives.....	6
Total	9

Biosystems Engineering. This emphasis is designed to strengthen the background of students interested in physiological systems modeling and analysis and design and evaluation of artificial organs and medical devices. Analyzing physiological systems and designing artificial organs requires knowledge in integrating electrical, mechanical, transport, and thermofluid systems. Students considering careers in medical device industries, clinical engineering, or artificial organs should consider this area of emphasis.

Technical electives must include the following:

BME 350 Signals and Systems for Bioengineers.....	3
or BME 419 Biocontrol Systems (3)	—
BME 411 Biomedical Engineering I.....	3
or BME 412 Biomedical Engineering II (3)	—
BME 415 Biomedical Transport Processes	3
Total	9

Molecular and Cellular Bioengineering. This emphasis is designed to strengthen and integrate the student's knowledge of molecular and cellular biology, biochemistry, and

biomaterials science and engineering for the design of biomolecular and cellular-based hybrid medical and diagnostic devices. It is particularly suited for students interested in pursuing graduate studies in molecular and cellular bioengineering and health-related biotechnology. Technical electives must include the following:

BIO 353 Cell Biology	3
CHM 331 General Organic Chemistry	3
CHM 361 Principles of Biochemistry.....	3
Total	9

Premedical Engineering. This emphasis is designed to meet the needs of students desiring entry into a medical, dental, or veterinary school. The course sequence provides an excellent background for advanced study leading to a career in research in the medical or life sciences. Technical electives must include the following:

CHM 331 General Organic Chemistry	3
CHM 332 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory.....	1
CHM 336 General Organic Chemistry Laboratory.....	1
Total	8

To fulfill medical school admission requirements, BIO 182 General Biology is also required in addition to the degree requirements.

Bioengineering Program of Study Typical Four-Year Sequence

First Year

First Semester	
CHM 113 General Chemistry <i>SI/S2</i>	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>	4
Total	15

Second Semester

CHM 116 General Chemistry <i>SI/S2</i>	4
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>NI</i>	4
PHY 121 University Physics I: Mechanics <i>SI/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>SI/S2</i> ¹	1
Total	15

Second Year

First Semester

BIO 181 General Biology <i>SI/S2</i>	4
BME 201 Introduction to Bioengineering <i>LI</i>	3
ECE 210 Engineering Mechanics I: Statics.....	3
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>SI/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>SI/S2</i> ²	1
Total	18

Second Semester

ECE 301 Electrical Networks I.....	4
ECE 350 Structure and Properties of Materials	3
MAT 274 Elementary Differential Equations <i>NI</i>	3

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

HU, SB, and awareness area courses ³	6
Total	16

Third Year

First Semester

BME 331 Biomedical Engineering Transport I: Fluids.....	3
BME 435 Physiology for Engineers.....	4
ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 340 Thermodynamics.....	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
MAT 242 Elementary Linear Algebra	2
or ECE 384 Numerical Analysis for Engineers I (2)	
or ECE 386 Partial Differential Equations for Engineers (2)	
Total	18

Second Semester

BME 318 Biomaterials	3
BME 334 Bioengineering Heat and Mass Transfer.....	3
ECE 334 Electronic Devices and Instrumentation	4
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
HU, SB, and awareness area courses ³	4
Total	17

Fourth Year

First Semester

BME 413 Biomedical Instrumentation <i>L2</i>	3
BME 416 Biomechanics.....	3
BME 417 Biomedical Engineering Capstone Design I.....	3
BME 423 Biomedical Instrumentation Laboratory <i>L2</i>	1
HU, SB, and awareness area course ³	3
Technical electives	3
Total	16

Second Semester

BME 470 Microcomputer Applications in Bioengineering.....	4
BME 490 Biomedical Engineering Capstone Design II.....	3
Technical electives	6
Total	13
Total degree requirements.....	128

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

MATERIALS SCIENCE AND ENGINEERING—B.S.E.

REGENTS' PROFESSOR

MAYER

PROFESSORS

ADAMS, DEY, KRAUSE, MAHAJAN

ASSOCIATE PROFESSOR

ALFORD

Materials science and engineering is concerned with the study of fundamental relationships between the structure and processing of materials and their properties. The program develops a knowledge of materials that allows graduates to decide how to optimize design of engineering

components with existing materials or how to develop new advanced materials and processing techniques.

All major industries and many research laboratories are involved with the selection, utilization, and development of materials used for designing and producing engineering systems. Students who major in materials science and engineering will find employment opportunities in a variety of industries and research facilities which include aerospace, automotive, electronics, energy conversion, manufacturing, medical devices, and semiconductors.

The responsibilities of a materials engineer include research and development of materials to meet new demands of advancing technologies, to select the best material for a specific application, and to devise novel processing methods to improve the performance or cost of a material in an engineering component.

In essence, a materials engineer uses the fundamental principles of chemistry and physics for the benefit of mankind in areas such as communication, computation, medicine, and transportation.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Materials Science and Engineering. A minimum of 50 upper-division semester hours is required.

Graduation Requirements. In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 81.

Course Requirements. The undergraduate curriculum requires that students take a series of interdisciplinary courses of fundamental importance to an understanding of all engineering materials. Following these are additional courses that may be taken as technical electives to develop an area of emphasis. The courses for the undergraduate degree can be classified into the following categories (in semester hours):

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
or	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
or	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i>	
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
HU, SB, and awareness area courses	13
Total	16
<i>Literacy and Critical Inquiry</i>	
ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 400 Engineering Communications <i>L2</i>	3
Total	6
<i>Natural Sciences/Basic Sciences</i>	
CHM 113 General Chemistry <i>S1/S2</i>	4

CHM 116 General Chemistry S1/S2	4
PHY 121 University Physics I: Mechanics S1/S2 ¹	3
PHY 122 University Physics Laboratory S1/S2 ¹	1
PHY 131 University Physics II: Electricity and Magnetism S1/S2 ²	3
PHY 132 University Physics Laboratory II S1/S2 ²	1
Total	16

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design N3	4
MAT 242 Elementary Linear Algebra	2
or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	
MAT 270 Calculus with Analytic Geometry I N1	4
MAT 271 Calculus with Analytic Geometry II N1	4
MAT 272 Calculus with Analytic Geometry III N1	4
MAT 274 Elementary Differential Equations N1	3
Total	21

General Studies/school requirements total	59
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Engineering Core

ECE 210 Engineering Mechanics I: Statics	3
ECE 301 Electrical Networks I	4
ECE 313 Introduction to Deformable Solids	3
ECE 350 Structure and Properties of Materials	3
MSE 430 Thermodynamics of Materials	3
Total	16

Major

ECE 380 Probability and Statistics for Engineering Problem Solving N2	3
MSE 353 Introduction to Materials Processing and Synthesis	3
MSE 354 Experiments in Materials Synthesis and Processing I	2
MSE 355 Introduction to Materials Science and Engineering	3
MSE 420 Physical Metallurgy	3
MSE 421 Physical Metallurgy Laboratory	1
MSE 440 Mechanical Properties of Solids	3
MSE 450 X-ray and Electron Diffraction	3
MSE 470 Polymers and Composites	3
MSE 471 Introduction to Ceramics	3
MSE 482 Materials Engineering Design	3
MSE 490 Capstone Design Project	3
Select two of the following four courses ³	6
CHM 325 Analytical Chemistry (3)	
CHM 331 General Organic Chemistry (3)	
CHM 341 Elementary Physical Chemistry (3)	
PHY 361 Introductory Modern Physics (3)	
Technical electives ⁴	8
Total	47

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ In order to take CHM 341 Elementary Physical Chemistry, CHM 331 Organic Chemistry must be taken as the prerequisite.

⁴ Three of the eight hours must be a non-MSE upper-division engineering elective course.

Materials Science and Engineering Areas of Emphasis

Technical electives may be selected from one or more of the following areas. A student may, with prior approval of the department, select a general area or a set of courses that

would support a career objective not covered by the following categories.

Biomaterials. Students interested in the materials used in the body and other living systems to improve or replace body components should choose from the following technical electives:

BME 318 Biomaterials	3
BME 411 Biomedical Engineering I	3
BME 412 Biomedical Engineering II	3
BME 413 Biomedical Instrumentation L2	3
BME 416 Biomechanics	3

Ceramic Materials. Students who want to develop an understanding of the chemistry and processing that control the structure and properties of ceramics and their application should select from these technical electives:

CHM 331 General Organic Chemistry	3
CHM 332 General Organic Chemistry	3
CHM 471 Solid-State Chemistry	3
EEE 435 Microelectronics	3
EEE 436 Fundamentals of Solid-State Devices	3
EEE 439 Semiconductor Facilities and Cleanroom Practices	3
MSE 453 Experiments in Materials Synthesis and Processing II	2
MSE 454 Advanced Materials Processing and Synthesis	3
MSE 472 Integrated Circuit Materials Science	3

Energy Systems. Students interested in the materials used in energy conversion systems such as solar energy or nuclear energy should choose from the following technical electives:

MAE 441 Principles of Design	3
MAE 442 Mechanical Systems Design	3
MSE 431 Corrosion and Corrosion Control	3
MSE 441 Analysis of Material Failures	3

Integrated Circuit Materials. Students interested in the materials used in the semiconductor industry and in how they are processed to achieve the desired properties should choose from the following technical electives:

CHE 458 Semiconductor Material Processing	3
EEE 435 Microelectronics	3
EEE 436 Fundamentals of Solid-State Devices	3
EEE 439 Semiconductor Facilities and Cleanroom Practices	3
MSE 453 Experiments in Materials Synthesis and Processing II	2
MSE 454 Advanced Materials Processing and Synthesis	3
MSE 471 Introduction to Ceramics	3

Manufacturing and Materials Processing. Students interested in the manufacturing and processing of materials for a broad base of applications should choose from the following technical electives:

CHE 458 Semiconductor Material Processing	3
MAE 422 Mechanics of Materials	4
MAE 441 Principles of Design	3
MAE 442 Mechanical Systems Design	3
MSE 431 Corrosion and Corrosion Control	3
MSE 441 Analysis of Material Failures	3
MSE 453 Experiments in Materials Synthesis and Processing II	2

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

MSE 454 Advanced Materials Processing and Synthesis.....	3
MSE 472 Integrated Circuit Materials Science.....	3

Mechanical Metallurgy. Students interested in the materials used in the semiconductor industry and in how they are processed to achieve the desired properties should choose from the following technical electives:

MAE 415 Vibration Analysis.....	4
MAE 422 Mechanics of Materials.....	4
MAE 441 Principles of Design.....	3
MAE 442 Mechanical Systems Design.....	3
MSE 431 Corrosion and Corrosion Control.....	3
MSE 441 Analysis of Materials Failures.....	3

Metallic Materials Systems. Students interested in building an understanding of the basis for the design and processing of metals and alloys should choose from the following technical electives:

MAE 351 Manufacturing Processes.....	3
MSE 431 Corrosion and Corrosion Control.....	3
MSE 441 Analysis of Material Failures.....	3
MSE 472 Integrated Circuit Materials Science.....	3

Polymers and Composites. Students who desire to build an understanding of the chemical and processing basis for the properties of polymers and their applications, including composite systems, should select from the following technical electives:

CHM 331 General Organic Chemistry.....	3
CHM 332 General Organic Chemistry.....	3
CHM 471 Solid-State Chemistry.....	3
MSE 441 Analysis of Material Failures.....	3
MSE 472 Integrated Circuit Materials Science.....	3

**Materials Science and Engineering
Program of Study
Typical Four-Year Sequence**

First Year

First Semester

CHM 113 General Chemistry <i>S1/S2</i>	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>	4
Total.....	15

Second Semester

CHM 116 General Chemistry <i>S1/S2</i>	4
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>NI</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
Total.....	15

Second Year

First Semester

ECE 210 Engineering Mechanics I: Statics.....	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
MAT 242 Elementary Linear Algebra.....	2
or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
Total.....	16

Second Semester

ECE 301 Electrical Networks I.....	4
ECE 313 Introduction to Deformable Solids.....	3
ECE 350 Structure and Properties of Materials.....	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
MAT 274 Elementary Differential Equations <i>NI</i>	3
Total.....	16

Third Year

First Semester

ECE 300 Intermediate Engineering Design <i>L1</i>	3
MSE 353 Introduction to Materials Processing and Synthesis.....	3
MSE 355 Introduction to Materials Science and Engineering.....	3
Advanced science course ⁴	3
HU, SB, and awareness area courses ³	4
Total.....	16

Second Semester

MSE 354 Experiments in Materials Synthesis and Processing I...2	
MSE 420 Physical Metallurgy.....	3
MSE 421 Physical Metallurgy Laboratory.....	1
MSE 430 Thermodynamics of Materials.....	3
MSE 450 X-ray and Electron Diffraction.....	3
HU, SB, and awareness area courses ³	6
Total.....	18

Fourth Year

First Semester

MSE 440 Mechanical Properties of Solids.....	3
MSE 470 Polymers and Composites.....	3
MSE 471 Introduction to Ceramics.....	3
MSE 482 Materials Engineering Design.....	3
Technical elective.....	4
Total.....	16

Second Semester

ECE 400 Engineering Communications <i>L2</i>	3
MSE 490 Capstone Design Project.....	3
Advanced science course ⁴	3
HU, SB, and awareness area course ³	3
Technical electives.....	4
Total.....	16
Degree requirements total.....	128

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

⁴ In order to take CHM 341 Elementary Physical Chemistry, CHM 331 Organic Chemistry must be taken as the prerequisite.

BIOENGINEERING (BME)

BME 201 Introduction to Bioengineering. (3) F

Impact of bioengineering on society. Developing an awareness of the contributions of bioengineering to solve medical and biological problems. Cross-listed as STE 201. Credit is allowed for only BME 201 or STE 201. Prerequisite: ENG 102 or 105 or 108. *General Studies: L1.*

BME 202 Global Awareness Within Biomedical Engineering Design. (3) N

Introduction to ethical, legal, social, economic, and technical issues arising from the design and implementation of bioengineering technology. Lecture, critical discourse. Prerequisites: ECE 100; ECN 111 or 112; ENG 102. *General Studies: L1/HU.*

BME 318 Biomaterials. (3) S

Material properties of natural and artificial biomaterials. Tissue and blood biocompatibility. Uses of materials to replace body parts. Prerequisite: ECE 350.

BME 331 Biomedical Engineering Transport I: Fluids. (3) F, S

Transport phenomena with emphasis on biomedical engineering fluid systems. Prerequisites: MAT 274; PHY 131.

BME 334 Bioengineering Heat and Mass Transfer. (3) S

Application of the principles of heat and mass transfer phenomena to solution of problems in medicine and medical device design. Prerequisite: ECE 340. Prerequisite with a grade of "C" or higher: BME 331.

BME 350 Signals and Systems for Bioengineers. (3) S

Application of principles of calculus and ordinary differential equations to modeling and analysis of responses, signals, and signal transfers in biosystems. Prerequisites: ECE 301; MAT 272, 274.

BME 411 Biomedical Engineering I. (3) A

Review of diagnostic and prosthetic methods using engineering methodology. Introduction to transport, metabolic, and autoregulatory processes in the human body. Prerequisite with a grade of "C" or higher: BME 334.

BME 412 Biomedical Engineering II. (3) A

Review of electrophysiology and nerve pacing applications, introduction to biomechanics and joint/limb replacement technology, cardiovascular and pulmonary fluid mechanics, and the application of mathematical modeling. Prerequisite: instructor approval.

BME 413 Biomedical Instrumentation. (3) F

Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems. Prerequisites: ECE 300, 334. Prerequisite with a grade of "C" or higher: BME 435. Corequisite: BME 423. *General Studies: L2.*

BME 415 Biomedical Transport Processes. (3) A

Principles of momentum, heat, and mass transport with applications to medical and biological systems and medical device design. Prerequisites: MAT 274; PHY 131.

BME 416 Biomechanics. (3) F

Mechanical properties of bone, muscle, and soft tissue. Static and dynamic analysis of human movement tasks such as locomotion. Prerequisite with a grade of "C" or higher: BME 318.

BME 417 Biomedical Engineering Capstone Design I. (3) F

Technical, regulatory, economic, legal, social, and ethical aspects of medical device systems engineering design. Lecture, field trips. Prerequisites with a grade of "C" or higher: BME 318, 334.

BME 419 Biocontrol Systems. (3) F

Application of linear and nonlinear control systems techniques toward analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body. Prerequisites: ECE 301; MAT 274.

BME 423 Biomedical Instrumentation Laboratory. (1) F

Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Prerequisites: ECE 300, 334. Prerequisite with a grade of "C" or higher: BME 435. Corequisite: BME 413. *General Studies: L2.*

BME 435 Physiology for Engineers. (4) F

Physiology of the nervous, muscular, cardiovascular, endocrine, renal, and respiratory systems. Emphasizes use of quantitative methods in understanding physiological systems. Lecture, lab. Prerequisites: BIO 181 and CHM 116 and PHY 131 or instructor approval.

BME 470 Microcomputer Applications in Bioengineering. (4) S

Use of microcomputers for real-time data collection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Prerequisites: ECE 100, 334. Prerequisite with a grade of "C" or higher: BME 435.

BME 490 Biomedical Engineering Capstone Design II. (1–5) F, S

Individual projects in medical systems or medical device design and development. Lecture, lab. Prerequisite with a grade of "C" or higher: BME 417.

BME 496 Professional Seminar. (1–3) F, S

Professional and ethical aspects with a discussion of responsibilities. Lecture, field trips. Prerequisite: instructor approval.

BME 511 Biomedical Engineering. (3) A

Diagnostic and prosthetic methods using engineering methodology. Transport, metabolic, and autoregulatory processes in the body.

BME 512 Biomedical Engineering II. (3) A

Electrophysiology and nerve pacing applications, introduction to biomechanics and joint/limb replacement, technology, cardiovascular and pulmonary fluid mechanics, and mathematical modeling.

BME 513 Biomedical Instrumentation I. (3) F

Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems.

BME 514 Advanced Biomedical Instrumentation. (3) N

Principles of applied biophysical measurements using bioelectric and radiological approach. Prerequisites: ECE 334; MAT 274 (or equivalent).

BME 515 Biomedical Transport Processes. (3) N

Principles of momentum, heat, and mass transport with applications to medical and biological systems and medical device design. Prerequisite: instructor approval.

BME 516 Topics in Biomechanics. (3) F

Mechanical properties of bone, muscle, and soft tissue. Static and dynamic analysis of human movement tasks, including in-depth project. Prerequisite: instructor approval.

BME 518 Introduction to Biomaterials. (3) S

Topics include structure property relationships for synthetic and natural biomaterials, biocompatibility, and uses of materials to replace body parts. Prerequisite: ECE 350 or equivalent or instructor approval.

BME 519 Topics in Biocontrol Systems. (3) F

Linear and nonlinear control systems analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body, including in-depth project. Prerequisites: ECE 301 and MAT 274 or instructor approval.

BME 520 Bioelectric Phenomena. (3) N

Study of the origin, propagation, and interactions of bioelectricity in living things; volume conductor problem, mathematical analysis of bioelectric interactions, and uses in medical diagnostics.

BME 521 Neuromuscular Control Systems. (3) S

Overview of sensorimotor brain structures. Application of nonlinear, adaptive, optimal, and supervisory control theory to eye-head-hand coordination and locomotion.

BME 522 Biosensor Design and Application. (3) A

Theory and principles of biosensor design and application in medicine and biology. Principles of measurements with biosensors. Prerequisite: instructor approval.

BME 523 Physiological Instrumentation Lab. (1) F

Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Pre- or corequisites: AGB/BME 435; BME 413; ECE 334.

BME 524 Fundamentals of Applied Neural Control. (3) A

Fundamental concepts of electrical stimulation and recording in the nervous system with the goal of functional control restoration. Pre- or corequisite: BME 435 or instructor approval.

BME 525 Surgical Techniques. (2) S

Principles of surgical techniques, standard operative procedures, federal regulations, guidelines, and state-of-the-art methods. Lecture, lab.

BME 532 Prosthetic and Rehabilitation Engineering. (3) A

Analysis and critical assessment of design and control strategies for state-of-the-art medical devices used in rehabilitation engineering. Pre- or corequisite: BME 416 or 516 or EPE 610.

BME 533 Transport Processes I. (3) F

Unified treatment of momentum, heat, and mass transfer from molecular theory, and continuum points of view. Continuum equations of microscopic and macroscopic systems and multicomponent and multiphase systems. Cross-listed as CHE 533. Credit is allowed for only BME 533 or CHE 533.

BME 534 Transport Processes II. (3) S

Continuation of BME/CHE 533, emphasizing mass transfer. Cross-listed as CHE 534. Credit is allowed for only BME 534 or CHE 534. Prerequisite: BME/CHE 533.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

BME 543 Thermodynamics of Chemical Systems. (3) F

Classical and statistical thermodynamics of nonideal physicochemical systems and processes; prediction of optimum operating conditions. Cross-listed as CHE 543. Credit is allowed for only BME 543 or CHE 543.

BME 544 Chemical Reactor Engineering. (3) S

Reaction rates, thermodynamics, and transport principles applied to the design and operation of chemical reactors. Cross-listed as CHE 544. Credit is allowed for only BME 544 or CHE 544. Prerequisite: BME/CHE 543.

BME 551 Movement Biomechanics. (3) S

Mechanics applied to the analysis and modeling of physiological movements. Computational modeling of muscles, tendons, joints, and the skeletal system with application to sports and rehabilitation. Prerequisite: BME 416 or 516 or instructor approval.

BME 566 Medical Imaging Instrumentation. (3) N

Design and analysis of imaging systems and nuclear devices for medical diagnosis, therapy, and research. Laboratory experiments using diagnostic radiology, fluoroscopy, ultrasound, and CAT scanning. Lecture, lab. Prerequisite: instructor approval.

BME 568 Medical Imaging. (3) N

CT, SPECT, PET, and MRI. 3-dimensional *in vivo* measurements. Instrument design, physiological modeling, clinical protocols, reconstruction algorithms, and quantitation issues. Prerequisite: instructor approval.

CHEMICAL ENGINEERING (CHE)**CHE 311 Introduction to Chemical Processing.** (3) F, S

Application of chemical engineering analysis and problem solving to chemical processes material and energy balance methods and skills. Prerequisites: CHM 116; MAT 271.

CHE 331 Transport Phenomena I: Fluids. (3) F, S

Transport phenomena, with emphasis on fluid systems. Prerequisites: CHE 311; ECE 394 ST: Conservation Principles; MAT 274.

CHE 332 Transport Phenomena II: Energy Transfer. (3) F, S

Continuation of transport principles, with emphasis on energy transport in stationary and fluid systems. Prerequisite: CHE 331.

CHE 333 Transport Phenomena III: Mass Transfer. (3) F, S

The application of transport phenomena to mass transfer. The design of mass transfer equipment, including staged processes. Prerequisite: CHE 332.

CHE 342 Applied Chemical Thermodynamics. (4) F, S

Application of conservation and accounting principles with non-ideal property estimation techniques to model phase and chemical equilibrium processes. Lecture, recitation. Prerequisites: CHE 311; ECE 394 ST: Conservation Principles, ECE 394 ST: Properties that Matter. Pre- or corequisite: MAT 272.

CHE 352 Transport Laboratories. (3) S

The demonstration of transport phenomena principles with experiments in fluid flow, heat, and mass transfer. Prerequisites: CHE 332; ECE 300. Pre- or corequisite: CHE 333. *General Studies: L2.*

CHE 432 Principles of Chemical Engineering Design. (3) F

Multicomponent distillation, engineering economics, equipment sizing and costs, plant operation economics, and simulation and optimization techniques. Prerequisites: CHE 332, 342.

CHE 442 Chemical Reactor Design. (3) F, S

Application of kinetics to chemical reactor design. Prerequisite: CHE 342. Pre- or corequisite: CHE 333.

CHE 451 Chemical Engineering Laboratory. (2) F

Operation, control, and design of experimental and industrial process equipment; independent research projects. 6 hours lab. Prerequisites: CHE 333, 352; ECE 384.

CHE 458 Semiconductor Material Processing. (3) N

Introduction to the processing and characterization of electronic materials for semiconductor applications. Prerequisites: CHE 333, 342.

CHE 461 Process Control. (4) F

Process dynamics, instrumentation, and feedback applied to automatic process control. Lecture, lab. Prerequisite: ECE 394 ST: Engineering Systems. *General Studies: N3.*

CHE 462 Process Design. (3) S

Application of economic principles to optimize equipment selection and design; development and design of process systems. Prerequisites: CHE 432, 442.

CHE 474 Chemical Engineering Design for the Environment. (3) F

Conflict of processing materials and preserving the natural resources. Students will understand/value the environment and attempt to control our impact. Prerequisites: CHE 333, 342.

CHE 475 Biochemical Engineering. (3) N

Application of chemical engineering methods, mass transfer, thermodynamics, and transport phenomena to industrial biotechnology. Prerequisite: instructor approval.

CHE 476 Bioreaction Engineering. (3) N

Principles of analysis and design of reactors for processing with cells and other biologically active materials; applications of reaction engineering in biotechnology. Prerequisite: instructor approval.

CHE 477 Bioseparation Processes. (3) N

Principles of separation of biologically active chemicals; the application, scaleup, and design of separation processes in biotechnology. Prerequisite: instructor approval.

CHE 478 Industrial Water Quality Engineering. (3) F

Chemical treatment processing, quality criteria and control, system design, and water pollutants. Prerequisites: CHE 331; senior standing.

CHE 479 Air Quality Control. (3) F

Air pollutant control, effects, and origins. Chemical and physical processes, including combustion, control equipment design, dispersion, and sampling. Prerequisites: CHE 331; senior standing.

CHE 490 Chemical Engineering Projects. (1–5) F, S, SS

Individual projects in chemical engineering operations and design. Prerequisite: instructor approval.

CHE 494 ST: Special Topics. (1–4) F, S**CHE 496 Professional Seminar.** (1–3) F, S

Professional and ethical aspects with a discussion of responsibilities. Lecture, field trips. Prerequisite: instructor approval.

CHE 501 Introduction to Transport Phenomena. (3) F, S

Transport phenomena, with emphasis on fluid systems. Prerequisite: transition student with instructor approval.

CHE 502 Introduction to Energy Transport. (3) F, S

Continuation of transport principles, with emphasis on energy transport in stationary and fluid systems. Prerequisite: transition student with instructor approval.

CHE 503 Introduction to Mass Transport. (3) F, S

The application of transport phenomena to mass transfer. The design of mass transfer equipment, including staged processes. Prerequisite: transition student with instructor approval.

CHE 504 Introduction to Chemical Thermodynamics. (3) F, S

Energy relations and equilibrium conversions based on chemical potentials and phase equilibria. Prerequisite: transition student with instructor approval.

CHE 505 Introduction to Chemical Reactor Design. (3) F, S

Application of kinetics to chemical reactor design. Prerequisite: transition student with instructor approval.

CHE 527 Advanced Applied Mathematical Analysis in Chemical Engineering. (3) F

Formulation and solution of complex mathematical relationships resulting from the description of physical problems in mass, energy, and momentum transfer and chemical kinetics.

CHE 528 Process Optimization Techniques. (3) S

Method for optimizing engineering processes. Experimental design and analysis; linear and nonlinear regression methods; classical, search, and dynamic programming algorithms.

CHE 533 Transport Processes I. (3) F

Unified treatment of momentum, heat, and mass transfer from molecular theory, and continuum points of view. Continuum equations of microscopic and macroscopic systems and multicomponent and multiphase systems. Cross-listed as BME 533. Credit is allowed for only BME 533 or CHE 533.

CHE 534 Transport Processes II. (3) S

Continuation of CHE/BME 533, emphasizing mass transfer. Cross-listed as BME 534. Credit is allowed for only BME 534 or CHE 534. Prerequisite: BME/CHE 533.

CHE 536 Convective Mass Transfer. (3) N

Turbulent flow for multicomponent systems, including chemical reactions with applications in separations and air pollution. Prerequisite: CHE 533 or MAE 571.

- CHE 543 Thermodynamics of Chemical Systems.** (3) F
Classical and statistical thermodynamics of nonideal physicochemical systems and processes; prediction of optimum operating conditions. Cross-listed as BME 543. Credit is allowed for only BME 543 or CHE 543.
- CHE 544 Chemical Reactor Engineering.** (3) S
Reaction rates, thermodynamics, and transport principles applied to the design and operation of chemical reactors. Cross-listed as BME 544. Credit is allowed for only BME 544 or CHE 544. Prerequisite: BME/CHE 543.
- CHE 548 Topics in Catalysis.** (3) N
Engineering catalysis, emphasizing adsorption, kinetics, characterization, diffusional considerations, and reactor design. Other topics include mechanisms, surface analyses, and electronic structure.
- CHE 552 Industrial Water Quality Engineering.** (3) N
Water pollutants, quality criteria and control, chemical treatment processing, and system design. Case studies. Prerequisite: CHE 331 or equivalent.
- CHE 553 Air Quality Control.** (3) N
Air pollutant origins, effects, and control. Physical and chemical processes, including dispersion, combustion, sampling, control equipment design, and special topics. Prerequisite: CHE 331 or equivalent.
- CHE 554 New Energy Technology.** (3) N
Gasification, liquefaction pyrolysis, and combustion processes for coal, wastes, and other raw materials. In-situ processes for coal, oil, shale, and geothermal energy. Environmental quality issues.
- CHE 556 Separation Processes.** (3) N
Topics in binary/multicomponent separation, rate governed and equilibrium processes, mass transfer criteria, energy requirements, separating agents and devices, and staged operations.
- CHE 558 Electronic Materials.** (3) N
Processing and characterization of electronic materials for semiconductor type uses. Thermodynamics and transport phenomena, phase equilibria and structure, mass transfer, and diffusion and thermal properties.
- CHE 561 Advanced Process Control.** (3) S
Dynamic process representation, linear optimal control, optimal state reconstruction, and parameter and state estimation techniques for continuous and discrete time systems.
- CHE 563 Chemical Engineering Design.** (3) N
Computational methods; the design of chemical plants and processes.

MATERIALS SCIENCE AND ENGINEERING (MSE)

- MSE 353 Introduction to Materials Processing and Synthesis.** (3) F
Principles of materials structure and properties with emphasis on applications in bulk and thin film materials processing and synthesis. Prerequisites: CHM 116 and PHY 131 or equivalents.
- MSE 354 Experiments in Materials Synthesis and Processing I.** (2) S
Small groups of students complete three experiments selected from a list. Each is supervised by a selected faculty member. Lab. Prerequisite: MSE 353 or equivalent.
- MSE 355 Introduction to Materials Science and Engineering.** (3) F
Elements of the structure of metals and alloys, measurement of mechanical properties, and optical metallography. Lecture, lab, field trips. Prerequisite: CHM 114 or 116.
- MSE 420 Physical Metallurgy.** (3) F
Crystal structure and defects. Phase diagrams, metallography, solidification and casting, deformation, and annealing. Prerequisite: ECE 350.
- MSE 421 Physical Metallurgy Laboratory.** (1) S
Focuses on analysis of microstructure of metals and alloys and includes correlation with mechanical properties to some extent. Lab. Pre- or corequisite: MSE 420.
- MSE 430 Thermodynamics of Materials.** (3) S
Principles of statistical mechanics, statistical thermodynamics of single crystals, solutions, phase equilibrium, free energy of reactions, free electron theory, and thermodynamics of defects. Prerequisite: ECE 350.
- MSE 431 Corrosion and Corrosion Control.** (3) S
Introduction to corrosion mechanisms and methods of preventing corrosion. Topics include the following: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: ECE 350.
- MSE 440 Mechanical Properties of Solids.** (3) S
Effects of environmental and microstructural variables of mechanical properties, including plastic deformation, fatigue, creep, brittle fracture, and internal friction. Prerequisite: ECE 350.
- MSE 441 Analysis of Material Failures.** (3) S
Identification of types of failures. Analytical techniques. Fractography, SEM, nondestructive inspection, and metallography. Mechanical and electronic components. Prerequisite: ECE 350.
- MSE 450 X-ray and Electron Diffraction.** (3) F
Fundamentals of X-ray diffraction, transmission electron microscopy, and scanning electron microscopy. Techniques for studying surfaces, internal microstructures, and fluorescence. Lecture, demonstrations. Prerequisite: ECE 350.
- MSE 453 Experiments in Materials Synthesis and Processing II.** (2) F
A continuation of MSE 354, with emphasis on characterization. Small groups complete three experiments supervised by selected faculty members. Lab. Prerequisites: MSE 353 and 354 or equivalents.
- MSE 454 Advanced Materials Processing and Synthesis.** (3) S
Case studies from published literature of current techniques in materials processing and synthesis. Student participation in classroom presentations. Lecture, recitation. Prerequisites: MSE 353 and 354 or equivalents.
- MSE 470 Polymers and Composites.** (3) F
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MAE 455. Credit is allowed for only MAE 455 or MSE 470. Prerequisite: ECE 350.
- MSE 471 Introduction to Ceramics.** (3) F
Principles of structure and property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: ECE 350.
- MSE 472 Integrated Circuit Materials Science.** (3) N
Principles of materials science applied to semiconductor processing and fabrication in metals, ceramics, polymers, and semiconductors. Prerequisite: ECE 350.
- MSE 482 Materials Engineering Design.** (3) F, S
Principles of the design process. Feasibility and optimization. Manufacturing processes, materials selection, failure analysis, and economics. Prerequisites: ECE 313, 350.
- MSE 490 Capstone Design Project.** (1–3) F, S
For small groups in fundamental or applied aspects of engineering materials; emphasis on experimental problems and design. Prerequisites: MSE 430, 440, 450.
- MSE 496 Professional Seminar.** (1–3) F, S
Professional and ethical aspects with a discussion of responsibilities. Lectures, field trips. Prerequisite: instructor approval.
- MSE 510 X-ray and Electron Diffraction.** (3) F
Fundamentals of X-ray diffraction, transmission electron microscopy, and scanning electron microscopy. Techniques for studying surfaces, internal microstructures, and fluorescence. Lecture, demonstrations. Prerequisite: transition student with instructor approval.
- MSE 511 Corrosion and Corrosion Control.** (3) S
Introduction to corrosion mechanisms and methods of preventing corrosion. Topics include the following: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: transition student with instructor approval.
- MSE 512 Analysis of Material Failures.** (3) S
Identification of types of failures. Analytical techniques. Fractography, SEM, nondestructive inspection, and metallography. Mechanical and electronic components. Prerequisite: transition student with instructor approval.
- MSE 513 Polymers and Composites.** (3) F
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

MSE 514 Physical Metallurgy. (3) S

Crystal structure and defects. Phase diagrams, metallography, solidification and casting, and deformation and annealing. Prerequisite: transition student with instructor approval.

MSE 515 Thermodynamics of Materials. (3) N

Principles of statistical mechanics, statistical thermodynamics of single crystals, solutions, phase equilibrium, free energy of reactions, free electron theory, and thermodynamics of defects. Prerequisite: transition student with instructor approval.

MSE 516 Mechanical Properties of Solids. (3) S

Effects of environmental and microstructural variables of mechanical properties, including plastic deformation, fatigue, creep, brittle fracture, and internal friction. Prerequisite: transition student with instructor approval.

MSE 517 Introduction to Ceramics. (3) F

Principles of structure, property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: transition student with instructor approval.

MSE 518 Integrated Circuits Materials Science. (3) N

Principles of materials science applied to semiconductor processing and fabrication in metals, ceramics, polymers, and semiconductors. Prerequisite: transition student with instructor approval.

MSE 520 Theory of Crystalline Solids. (3) F

Anisotropic properties of crystals; tensor treatment of elastic, magnetic, electric and thermal properties, and crystallography of Martensitic transformations.

MSE 521 Defects in Crystalline Solids. (3) S

Introduction to the geometry, interaction, and equilibrium between dislocations and point defects. Relations between defects and properties will be discussed. Prerequisite: ECE 350 or instructor approval.

MSE 530 Materials Thermodynamics and Kinetics. (3) S

Thermodynamics of alloy systems, diffusion in solids, kinetics of precipitation, and phase transformations in solids. Prerequisites: ECE 340, 350.

MSE 540 Fracture, Fatigue, and Creep. (3) F

Relationship between microstructure and fracture; fatigue and creep properties of materials. Environmental effects and recent developments. Current theories and experimental results. Prerequisite: MSE 440 or equivalent.

MSE 550 Advanced Materials Characterization. (3) N

Analytical instrumentation for characterization of materials; SEM, SIMS, Auger, analytical TEM, and other advanced research techniques.

MSE 556 Electron Microscopy Laboratory. (3) F

Lab support for MSE 558. Cross-listed as SEM 556. Credit is allowed for only MSE 556 or SEM 556. Pre- or corequisite: MSE/SEM 558.

MSE 557 Electron Microscopy Laboratory. (3) S

Lab support for MSE 559. Cross-listed as SEM 557. Credit is allowed for only MSE 557 or SEM 557. Pre- or corequisite: MSE/SEM 559.

MSE 558 Electron Microscopy I. (3) F

Microanalysis of the structure and composition of materials using images, diffraction and X-ray, and energy loss spectroscopy. Knowledge of elementary crystallography, reciprocal lattice, stereographic projections, and complex variables is required. Cross-listed as SEM 558. Credit is allowed for only MSE 558 or SEM 558. Prerequisite: instructor approval.

MSE 559 Electron Microscopy II. (3) S

Microanalysis of the structure and composition of materials using images, diffraction and X-ray, and energy loss spectroscopy. Knowledge of elementary crystallography, reciprocal lattice, stereographic projections, and complex variables is required. Cross-listed as SEM 559. Credit is allowed for only MSE 559 or SEM 559. Prerequisite: instructor approval.

MSE 560 Strengthening Mechanisms. (3) S

Deformation of crystalline materials. Properties of dislocations. Theories of strain hardening, solid solution, precipitation, and transformation strengthening. Prerequisite: ECE 350 or equivalent.

MSE 561 Phase Transformation in Solids. (3) N

Heterogeneous and homogeneous precipitation reactions, shear displacive reactions, and order-disorder transformation.

MSE 562 Ion Implantation. (3) S

Includes defect production and annealing. Generalized treatment, including ion implantation, neutron irradiation damage, and the interaction of other incident beams. Prerequisite: MSE 450.

MSE 570 Polymer Structure and Properties. (3) F

Relationships between structure and properties of synthetic polymers, including glass transition, molecular relaxations, crystalline state viscoelasticity, morphological characterization, and processing.

MSE 571 Ceramics. (3) A

Includes ceramic processing, casting, molding, firing, sintering, crystal defects, and mechanical, electronic, and physical properties. Prerequisites: MSE 521, 561.

MSE 573 Magnetic Materials. (3) A

Emphasis on ferromagnetic and ferrimagnetic phenomena. Domains, magnetic anisotropy, and magnetostriction. Study of commercial magnetic materials. Prerequisite: MSE 520 or equivalent.

Department of Civil and Environmental Engineering

Sandra L. Houston

Chair

(ECG 252) 480/965-3589

www.eas.asu.edu/~civil

PROFESSORS

S. HOUSTON, W. HOUSTON, MAMLOUK,
MATTHIAS, MAYS, RAJAN, SINGHAL

ASSOCIATE PROFESSORS

DUFFY, FAFITIS, FOX, HINKS, JOHNSON

ASSISTANT PROFESSORS

BAKER, MUCCINO, OWUSU-ANTWI,
WESTERHOFF, ZHU

CIVIL ENGINEERING

The civil engineering profession includes analysis, planning, design, construction, and maintenance of many types of facilities for government, commerce, industry, and the public domain. These facilities include high-rise office towers, factories, schools, airports, tunnels and subway systems, dams, canals, and water purification and environmental protection facilities such as solid waste and wastewater treatment systems. Civil engineers are concerned with the impact of their projects on the public and the environment, and they attempt to coordinate the needs of society with technical and economic feasibility.

Career Opportunities in the Field. University graduates with the B.S.E. degree in Civil Engineering readily find employment. Civil engineers work in many different types of companies, from large corporations to small, private consulting firms, or in governmental agencies. A civil engineering background is an excellent foundation for jobs in management and public service. Civil engineering is one of the best engineering professions from the viewpoint of international travel opportunities or for eventually establishing one's own consulting business.

Uniqueness of the Program at ASU. The faculty in the Department of Civil and Environmental Engineering at ASU offer a challenging program of study designed to provide the student with the resources and background to pursue a career in a wide range of specialty areas. Some of these areas are structural, geotechnical, environmental and water resources, transportation and materials engineering.

The Civil Engineering program is fully accredited by ABET. With the program, students will be prepared for the Fundamentals of Engineering (FE) examination and professional registration.

The Department of Civil and Environmental Engineering offers challenging programs of study designed to provide students with the scientific and technical resources to pursue a broad and multifaceted range of careers.

Civil Engineering Areas of Study

Areas of study in the civil engineering curriculum are described below.

Environmental Engineering. This area of study includes the quality of air, water, and land resources; transport, use, and disposal of hazardous wastes; water and wastewater treatment; and water reuse.

Geotechnical Engineering. This area of study includes the analysis and design of foundation systems, seepage control, earthdams and water resource structures, earthwork operations, fluid flow-through porous media, and response of foundations and embankments to earthquakes.

Structural Engineering. This area of study considers the planning, analysis and design of steel and concrete bridges, buildings, dams; special offshore and space structures; composite materials.

Transportation and Materials Engineering. This area of study is pursued in two major areas and several interrelated areas: (1) transportation planning, design, and operation, and (2) pavements and materials. Transportation planning, design, and operation emphasizes the highway mode but also encompasses public transit and airport planning and design. Urban transport planning, geometric design of facilities, traffic operations, and evaluation of highway capacity and safety are also a part of transportation planning. The application of advanced technology to the vehicle and the roadway is included in the study of intelligent vehicle/highway systems. Pavements and materials focus on pavement analysis and design; pavement maintenance and rehabilitation; pavement evaluation and management; and characterization of highway materials such as asphalt, concrete, portland cement, and portland cement concrete; durability of highway structures; and structural retrofit of existing bridges.

Water Resources Engineering. This area of study is concerned with surface and groundwater flow, planning and management of water supply, and water distribution system modeling.

The undergraduate program provides an excellent background for entry to graduate study in engineering.

Environmental Engineering Option

The environmental engineering option has been developed and implemented at ASU to augment the environmental area of study in the traditional civil engineering curriculum. Environmental engineering is a multidisciplinary field based on the traditional engineering principles, and chemistry, biology, and geology. Environ-

mental engineers are involved with the design and operation of water and wastewater treatment systems, remediation of contaminated soils and waters, construction of hazardous waste containment systems, analysis of the fate and transport of pollutants in natural environments, water conservation and reuse, and surface water quality management.

Career Opportunities in the Field. University graduates with the B.S.E. in Civil Engineering (environmental engineering option) find employment in consulting firms, municipalities, regulatory agencies, and industry. The growth of environmental engineering positions has been balanced by the growing number of students entering the field, resulting in a stable job market. International opportunities are great and are likely to expand. After earning the undergraduate B.S.E. degree in Civil Engineering (environmental engineering option), many students continue their education by enrolling in an environmental engineering graduate degree program.

Uniqueness of the Program at ASU. The environmental engineering option at ASU is presently one of a few such programs in the country. The curriculum includes a solid core of engineering fundamentals, in accordance with an ABET-accredited Civil and Environmental Engineering degree program, so that students will be prepared for the Fundamentals of Engineering (FE) examination and professional registration. The curriculum also includes a strong emphasis on chemistry, microbiology, and water and wastewater treatment processes.

ENTRANCE REQUIREMENTS

See “Admission,” page 196 and “Degrees,” page 198, for information regarding entrance requirements.

DEGREE REQUIREMENTS

The B.S.E. degree in Civil Engineering and the B.S.E. degree in Civil Engineering with an option in environmental engineering require a minimum of 128 semester hours of course work. A minimum of 50 upper-division semester hours is required. The minimum requirements are for a student who has successfully completed at least a year (each) of high school chemistry, physics, computer programming; and precalculus, algebra, and trigonometry.

The B.S.E. degree program consists of the following categories:

Civil Engineering	
First-Year Composition	6
General Studies/School Requirements	54
Engineering Core	19–20
Major	48–49
Total	128
Environmental Engineering Option	
First-Year Composition	6
General Studies/School Requirements	54
Engineering Core	19
Major	49
Total	128

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see “General Studies,” page 85. For graduation requirements, see “University Graduation Requirements,” page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see “Classification of Courses,” page 58.

Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See “University Graduation Requirements,” page 81.

Course Requirements. See “Degree Requirements,” page 199 and “Course Requirements,” page 208, for General Studies, school, and engineering core requirements.

DEGREE REQUIREMENTS FOR MAJOR IN CIVIL ENGINEERING

Civil Engineering Core

Twenty-seven hours are required. Each sequence of the MAT courses and the ECE courses (excluding ECE 300, 351, and 380) must be completed with an average grade of “C” or higher before any 400-level CEE courses are taken. Also, each sequence of the CEE courses, and the senior design and technical elective courses must be completed with an average grade of “C” or higher. All are part of the CEE graduation requirement.

CEE 296 Civil Engineering Systems.....	3
CEE 315 Computer Methods for Civil Engineers.....	1
CEE 321 Structural Analysis and Design.....	4
CEE 341 Fluid Mechanics for Civil Engineers.....	4
CEE 351 Geotechnical Engineering.....	4
CEE 361 Introduction to Environmental Engineering.....	4
CEE 372 Transportation Engineering.....	4
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
Total.....	27

Civil Engineering Design Electives

Six semester hours from the following list are required.

CEE 423 Structural Design.....	3
CEE 441 Water Resources Engineering.....	3
CEE 452 Foundations.....	3
CEE 466 Sanitary Systems Design.....	3
CEE 475 Highway Geometric Design.....	3

Civil Engineering Technical Electives

Fifteen to 16 semester hours are required. The design elective courses that have not been selected to satisfy the design electives requirement (see above) may be used as technical electives.

A maximum of seven hours may be selected from outside of civil engineering with advisor’s approval. Students must select technical electives from at least three different CEE areas of study.

Construction. A maximum of three hours may be selected from any of the following Construction (CON) courses.

CON 341 Surveying.....	3
CON 383 Construction Estimating.....	3
CON 495 Construction Planning and Scheduling <i>N3</i>	3
CON 496 Construction Contract Administration <i>L2</i>	3

Environmental Engineering. This area includes water treatment, industrial and domestic waste treatment and disposal, public health engineering, and industrial hygiene.

CEE 362 Unit Operations in Environmental Engineering.....	3
CEE 466 Sanitary Systems Design.....	3
CHM 231 Elementary Organic Chemistry <i>S1/S2</i>	3

MIC 220 Biology of Microorganisms.....	3
or MIC 205 Microbiology <i>S2</i> (3)	
and MIC 206 Microbiology Laboratory <i>S2</i> (1)	

Geotechnical Engineering. This area includes assessment of engineering properties and design utilizing soils and rocks as engineering materials.

CEE 452 Foundations.....	3
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Structural Engineering. This area includes analysis and design of structures for buildings, bridges, space frames, structural mechanics.

CEE 322 Steel Structures.....	3
CEE 323 Concrete Structures.....	3
CEE 423 Structural Design.....	3
CEE 432 Matrix and Computer Applications in Structural Engineering.....	3

Transportation/Materials Engineering. This area includes analysis and design of transportation facilities, transportation planning and economics, and transportation in the urban environment.

CEE 412 Pavement Analysis and Design.....	3
CEE 471 Intelligent Transportation Systems.....	3
CEE 475 Highway Geometric Design.....	3

Water Resources Engineering. This area includes planning and design of facilities for collection, storage and distribution of water, water systems management, and estimating availability of water resources.

CEE 440 Engineering Hydrology.....	3
CEE 441 Water Resources Engineering.....	3

Civil Engineering Program of Study A Four-Year Sequence

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
Total.....	15

Second Semester

CEE 296 Civil Engineering Systems.....	3
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
Total.....	14

Second Year

First Semester

ECE 210 Engineering Mechanics I: Statics.....	3
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
HU, SB, and awareness area course ³	3
Total.....	17

Second Semester

CEE 315 Computer Methods for Civil Engineers.....	1
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3

ECE 340 Thermodynamics.....3	
or ECE 301 Electrical Networks I (4)	
ECE 384 Numerical Analysis for Engineers I.....2	
ECN 111 Macroeconomic Principles <i>SB</i>3	
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
Basic science elective.....3	
Total18	

Third Year

First Semester

CEE 321 Structural Analysis and Design.....4	
CEE 341 Fluid Mechanics for Civil Engineers4	
ECE 300 Intermediate Engineering Design <i>L1</i>3	
ECE 351 Civil Engineering Materials3	
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>3	
Total17	

Second Semester

CEE 351 Geotechnical Engineering4	
CEE 361 Introduction to Environmental Engineering4	
CEE 372 Transportation Engineering.....4	
HU, SB, and awareness area course ³3	
Total15	

Fourth Year

First Semester

Design elective.....3	
HU, SB, and awareness area course(s) ³4	
Technical electives9	
Total16	

Second Semester

CEE 486 Integrated Civil Engineering Design <i>L2</i>3	
Design elective.....3	
HU, SB, and awareness area course ³3	
Technical electives6-7	
Total15-16	
Graduation requirement total128	

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.

A maximum of two graduate courses may be taken for undergraduate credit by students whose cumulative GPA is 3.00 or higher and with the approval of the instructor, advisor, department chair, and the dean of the college.

Concurrent Studies in Architecture and Civil Engineering

Undergraduate. Qualified lower-division students interested in combining studies in architecture and civil engineering may prepare for upper-division and graduate courses in both programs by taking courses listed in option B of the School of Architecture.

DEGREE REQUIREMENTS FOR ENVIRONMENTAL

ENGINEERING OPTION

Environmental Engineering Core

See "Course Requirements," page 214, for General Studies, school, and engineering core requirements.

Thirty semester hours are required. Each sequence of the MAT courses and the ECE courses (excluding ECE 300, 351, and 380) must be completed with an average grade of "C" or higher before any CEE 400-level courses are taken. Also, each sequence of the environmental engineering core courses, and the senior design and technical courses must be completed with an average grade of "C" or higher. This is a CEE graduation requirement.

CEE 296 Civil Engineering Systems.....3	
CEE 315 Computer Methods for Civil Engineers1	
CEE 321 Structural Analysis and Design.....4	
CEE 341 Fluid Mechanics for Civil Engineers4	
CEE 351 Geotechnical Engineering.....4	
CEE 361 Introduction to Environmental Engineering4	
CEE 372 Transportation Engineering.....4	
CHM 341 Elementary Physical Chemistry3	
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>3	
Total30	

Environmental Design Courses

CEE 441 Water Resources Engineering3	
CEE 466 Sanitary Systems Design.....3	
Total6	

Environmental Technical Courses

BIO 320 Fundamentals of Ecology3	
or PUP 442 Environmental Planning (3)	
or PUP 475 Environmental Impact Assessment (3)	
or CHM 302 Environmental Chemistry (3)	
or CHM 361 Principles of Biochemistry (3)	
CEE 362 Unit Operations in Environmental Engineering.....3	
CEE 440 Engineering Hydrology.....3	
MIC 205 Microbiology <i>S2</i>3	
MIC 206 Microbiology Laboratory <i>S2</i>1	
Total13	

Environmental Engineering Program of Study A Four-Year Sequence

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>S1/S2</i>4	
ECE 100 Introduction to Engineering Design <i>N3</i>4	
ENG 101 First-Year Composition.....3	
MAT 270 Calculus with Analytic Geometry I <i>N1</i>4	
Total15	

Second Semester

CEE 296 Civil Engineering Systems.....3	
ENG 102 First-Year Composition.....3	
MAT 271 Calculus with Analytic Geometry II <i>N1</i>4	
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹3	
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹1	
Total14	

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

Second Year

First Semester

ECE 210 Engineering Mechanics I: Statics.....	3
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
MAT 274 Elementary Differential Equations <i>NI</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
HU, SB, and awareness area course ³	3
Total	17

Second Semester

CEE 315 Computer Methods for Civil Engineers	1
CHM 231 Elementary Organic Chemistry <i>S1/S2</i>	3
ECE 312 Engineering Mechanics II: Dynamics	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 340 Thermodynamics.....	3
or ECE 301 Electrical Networks I (4)	
ECE 384 Numerical Analysis for Engineers I.....	2
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
Total	18

Third Year

First Semester

CEE 321 Structural Analysis and Design	4
CEE 341 Fluid Mechanics for Civil Engineers	4
ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 351 Civil Engineering Materials	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
Total	17

Second Semester

CEE 351 Geotechnical Engineering	4
CEE 361 Introduction to Environmental Engineering	4
CEE 372 Transportation Engineering.....	4
CHM 341 Elementary Physical Chemistry	3
HU, SB, and awareness area course ³	3
Total	18

Fourth Year

First Semester

CEE 362 Unit Operations in Environmental Engineering.....	3
CEE 440 Engineering Hydrology	3
CEE 466 Sanitary Systems Design.....	3
MIC 205 Microbiology <i>S2</i>	3
MIC 206 Microbiology Laboratory <i>S2</i>	1
HU, SB, and awareness area courses ³	4
Total	17

Second Semester

BIO 320 Fundamentals of Ecology	3
or CHM 302 Environmental Chemistry (3)	
or CHM 361 Principles of Biochemistry (3)	
or PUP 442 Environmental Planning (3)	
or PUP 475 Environmental Impact Assessment (3)	
CEE 441 Water Resources Engineering	3
CEE 486 Integrated Civil Engineering Design <i>L2</i>	3
HU, SB, and awareness area course ³	3
Total	12
Graduation requirement total	128

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.

A maximum of two graduate courses may be taken for undergraduate credit by students whose cumulative GPA is 3.00 or higher and with the approval of the instructor, advisor, department chair, and the dean of the college.

CIVIL AND ENVIRONMENTAL ENGINEERING (CEE)

CEE 296 Civil Engineering Systems. (3) F, S

Introduction to civil engineering. Problem solving, economics, description of civil engineering systems, design concepts, ethics, and professional responsibilities. Lecture, field trips. Pre- or corequisite: ECE 100.

CEE 310 Testing of Materials for Construction. (3) F, S

Structural and behavioral characteristics, engineering properties, measurements, and application of construction materials. Lecture, lab. Not open to engineering students. Prerequisite: CON 323.

CEE 315 Computer Methods for Civil Engineers. (1) F, S

Development of computer programs in a high-level language to solve civil engineering problems. Lecture, lab. Pre- or corequisite: ECE 384.

CEE 321 Structural Analysis and Design. (4) F, S

Statically determinate and indeterminate structures (trusses, beams, and frames) by classical and matrix methods. Introduction to structural design. Lecture, recitation. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 322 Steel Structures. (3) F

Behavior of structural components and systems. Design of steel members and connections. Load and resistance factor design methods. Lecture, recitation. Prerequisite: CEE 321.

CEE 323 Concrete Structures. (3) S

Behavior of concrete structures and the design of reinforced and pre-stressed concrete members, including footings. Partial design of concrete building system. Lecture, recitation. Prerequisite: CEE 321.

CEE 340 Hydraulics and Hydrology. (3) F, S

Application of hydraulic engineering principles to flow of liquids in pipe systems and open channels; hydrostatics; characteristics of pumps and turbines. Introduction to hydrology. Not open to engineering students. Lecture, lab. Prerequisite: CON 221.

CEE 341 Fluid Mechanics for Civil Engineers. (4) F, S

Fundamental principles and methods of fluid mechanics forming the analytical basis for water resources engineering. Conduit and open channel flow. 3 hours lecture, 1 hour lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 351 Geotechnical Engineering. (4) F, S

Index properties and engineering characteristics of soils. Compaction, permeability and seepage, compressibility and settlement, and shear strength. Lecture, lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 361 Introduction to Environmental Engineering. (4) F, S

Concepts of air and water pollution; environmental regulation, risk assessment, chemistry, water quality modeling, water and wastewater treatment systems designs. Lecture, lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 362 Unit Operations in Environmental Engineering. (3) S

Design and operation of unit processes for water and wastewater treatment. Prerequisite: CEE 361.

CEE 372 Transportation Engineering. (4) F, S

Highway, rail, water, and air transportation. Operational characteristics and traffic control devices of each transport mode. Impact on urban form. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 412 Pavement Analysis and Design. (3) F

Design of flexible and rigid pavements for highways and airports. Surface, base, and subgrade courses. Cost analysis and pavement selection. Prerequisites: CEE 351; ECE 351.

CEE 423 Structural Design. (3) F

Analysis and design of reinforced concrete steel, masonry, and timber structures. Lecture, lab. Prerequisite: CEE 323.

CEE 432 Matrix and Computer Applications in Structural Engineering. (3) S

Matrix and computer applications to structural engineering and structural mechanics. Stiffness and flexibility methods, finite elements, and differences. Prerequisite: CEE 321.

CEE 440 Engineering Hydrology. (3) F

Descriptive hydrology; hydrologic cycle, models, and systems. Rain-runoff models. Hydrologic design. Concepts, properties, and basic equations of groundwater flow. Prerequisite: CEE 341.

CEE 441 Water Resources Engineering. (3) S

Application of the principles of hydraulics and hydrology to the engineering of water resources projects; design and operation of water resources systems; water quality. Prerequisite: CEE 341.

CEE 450 Soil Mechanics in Construction. (3) F, S

Soil mechanics as applied to the construction field, including foundations, highways, retaining walls, and slope stability. Relationship between soil characteristics and geologic formations. Not open to engineering students. Lecture, lab. Prerequisite: CON 323.

CEE 452 Foundations. (3) F

Applications of soil mechanics to foundation systems, bearing capacity, lateral earth pressure, and slope stability. Prerequisite: CEE 351.

CEE 466 Sanitary Systems Design. (3) F

Capacity, planning and design of water supply, domestic and storm drainage, and solid waste systems. Prerequisite: CEE 361.

CEE 471 Intelligent Transportation Systems. (3) N

Application of advanced technology to the vehicle and the roadway to solve traffic congestion, safety, and air quality problems. Prerequisite: CEE 372 or instructor approval.

CEE 475 Highway Geometric Design. (3) S

Design of the visible elements of the roadway. Fundamental design controls with application to rural roads, at-grade intersections, free-ways, and interchanges. Lecture, recitation. Prerequisite: CEE 372.

CEE 486 Integrated Civil Engineering Design. (3) F, S

Students are required to complete a civil engineering design in a simulated practicing engineering environment. Lecture, team learning. Limited to undergraduates in their final semester. Prerequisites: CEE 321, 341, 351, 361, 372. *General Studies: L2.*

CEE 512 Pavement Performance and Management. (3) S

Pavement management systems, including data collection, evaluation, optimization, economic analysis, and computer applications for highway and airport design. Prerequisite: instructor approval.

CEE 514 Bituminous Materials and Mixture. (3) F

Types of bituminous materials used in pavement mixtures. Chemical composition, physical properties, desirable aggregate characteristics, optimum asphalt contents, superpave asphalt binder, mixture design. Lecture, lab. Prerequisite: ECE 351.

CEE 515 Properties of Concrete. (3) S

Materials science of concrete. Cement chemistry, mechanisms of hydration, interrelationships among micro and macro properties of cement-based materials. Mechanical properties, failure theories, fracture mechanics of concrete materials. Cement-based composite materials and the durability aspects. Lecture, lab. Prerequisite: ECE 350 or 351.

CEE 521 Stress Analysis. (3) F

Advanced topics in the analytical determination of stress and strain. Prerequisite: CEE 321.

CEE 524 Advanced Steel Structures. (3) F

Strength properties of steel and their effects on structural behavior. Elastic design of steel structures. Plastic analysis and design of beams, frames, and bents. Plastic deflections. Plastic design requirements. Multistory buildings. Prerequisite: CEE 322.

CEE 526 Finite Element Methods in Civil Engineering. (3) F

Finite element formulation for solutions of structural, geotechnical, and hydraulic problems. Prerequisite: CEE 432.

CEE 527 Advanced Concrete Structures. (3) S

Ultimate strength design. Combined shear and torsion. Serviceability. Plastic analysis. Special systems. Prerequisite: CEE 323.

CEE 530 Prestressed Concrete. (3) N

Materials and methods of prestressing. Analysis and design for flexure, shear, and torsion. Prestress losses due to friction, creep, shrinkage, and anchorage set. Statically indeterminate structures. Design of flat slabs, bridges, and composite beams. Prerequisite: CEE 323.

CEE 533 Structural Optimization. (3) N

Linear and nonlinear programming. Problem formulation. Constrained and unconstrained optimization. Sensitivity analysis. Approximate techniques. FEM-based optimal design of mechanical and aerospace structures. Cross-listed as MAE 521. Credit is allowed for only CEE 533 or MAE 521. Prerequisite: instructor approval.

CEE 536 Structural Dynamics. (3) S

Structures and structural members subjected to dynamic loadings, response spectra theory applications to bridges and power plants, investigations of the responses of multidegree of freedom structures, and matrix and numerical methods of analysis. Lecture, recitation. Prerequisites: CEE 321; instructor approval.

CEE 537 Topics in Structural Engineering. (1–3) F, S

Advanced topics, including nonlinear structural analysis, experimental stress analysis, advanced finite elements, plasticity and viscoelasticity, composites, and damage mechanics. Prerequisite: instructor approval.

CEE 540 Groundwater Hydrology. (3) F

Physical properties of aquifers, well pumping, subsurface flow modeling, unsaturated flow, numerical methods, land subsidence, and groundwater pollution. Prerequisite: CEE 440 or instructor approval.

CEE 541 Surface Water Hydrology. (3) S

Hydrologic cycle and mechanisms, including precipitation, evaporation, and transpiration; hydrograph analysis; flood routing; statistical methods in hydrology and hydrologic design. Prerequisite: CEE 440 or instructor approval.

CEE 542 Water Resources Systems Planning. (3) S

Philosophy of water resources planning; economic, social, and engineering interaction; introduction to the theory and application of quantitative planning methodologies in water resources planning. Guest lecturers, case studies. Prerequisite: instructor approval.

CEE 543 Water Resources Systems. (3) F

Theory and application of quantitative planning methodologies for the design and operation of water resources systems; class projects using a computer; case studies.

CEE 545 Foundations of Hydraulic Engineering. (3) F

Review of incompressible fluid dynamics. Flow in pipes and channels; unsteady and varied flows; wave motion. Prerequisite: CEE 341.

CEE 546 Free Surface Hydraulics. (3) S

Derivation of 1-dimensional equations used in open channel flow analysis; computations for uniform and nonuniform flows, unsteady flow, and flood routing. Mathematical and physical models. Prerequisite: CEE 341.

CEE 547 Principles of River Engineering. (3) N

Uses of rivers, study of watershed, and channel processes. Sediment sources, yield, and control; hydrologic analysis. Case studies. Prerequisite: CEE 341 or instructor approval.

CEE 548 Sedimentation Engineering. (3) N

Introduction to the transportation of granular sedimentary materials by moving fluids. Degradation, aggregation, and local scour in alluvial channels. Mathematical and physical models. Prerequisite: CEE 547 or instructor approval.

CEE 550 Soil Behavior. (3) S

Physicochemical aspects of soil behavior, stabilization of soils, and engineering properties of soils. Prerequisite: CEE 351.

CEE 551 Advanced Geotechnical Testing. (3) S

Odometer, triaxial (static and cyclic) back pressure saturated and unsaturated samples, pore pressure measurements, closed-loop computer-controlled testing, in-situ testing, and sampling. Lecture, lab. Prerequisite: CEE 351.

CEE 552 Geological Engineering. (3) F

Geological investigations for engineering purposes, case histories, geologic structure, weathering, remote sensing, geophysics, and air photo interpretation for engineering site locations. Lecture, field trips. Prerequisite: CEE 351.

CEE 553 Advanced Soil Mechanics. (3) N

Application of theories of elasticity and plasticity to soils, theories of consolidation, failure theories, and response to static and dynamic loading. Prerequisite: CEE 351.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

CEE 554 Shear Strength and Slope Stability. (3) F

Shear strength of saturated and unsaturated soils strength-deformation relationships, time-dependent strength parameters, effects of sampling, and advanced slope stability. Prerequisite: CEE 351.

CEE 555 Advanced Foundations. (3) N

Deep foundations, braced excavations, anchored bulkheads, reinforced earth, and underpinning. Prerequisite: CEE 351.

CEE 556 Seepage and Earth Dams. (3) N

Transient and steady state fluid flow through soil, confined and unconfined flow, pore water pressures, and application to earth dams. Prerequisite: CEE 351.

CEE 557 Hazardous Waste: Site Assessment and Mitigation Measures. (3) S

Techniques for hazardous waste site assessment and mitigation. Case histories presented by instructor and guest speakers. Prerequisites: graduate standing; instructor approval.

CEE 559 Earthquake Engineering. (3) F

Characteristics of earthquake motions, selection of design earthquakes, site response analyses, seismic slope stability, and liquefaction. Prerequisite: CEE 351.

CEE 560 Soil and Groundwater Remediation. (3) F

Techniques for remediation of contaminated soils and groundwaters are presented with basic engineering principles. Prerequisite: instructor approval.

CEE 561 Physical-Chemical Treatment of Water and Waste. (3) F

Theory and design of physical and chemical processes for the treatment of water and waste waters. Prerequisite: CEE 361.

CEE 562 Environmental Biochemistry and Waste Treatment. (3) S

Theory and design of biological waste treatment systems. Pollution and environmental assimilation of wastes. Prerequisite: CEE 362.

CEE 563 Environmental Chemistry Laboratory. (3) F

Analysis of water, domestic and industrial wastes, laboratory procedures for pollution evaluation, and the control of water and waste treatment processes. Lecture, lab. Prerequisite: CEE 361.

CEE 565 Modeling and Assessment of Aquatic Systems. (3) S

Development of predictive models of water quality; methods to assess environmental impacts; applications to water quality management. Prerequisite: CEE 361 or instructor approval.

CEE 566 Industrial/Hazardous Waste Treatment. (3) N

Emphasis on treatment of local industrial/hazardous waste problems, including solvent recovery and metals. Lecture, project. Prerequisites: CEE 561, 563.

CEE 573 Traffic Engineering. (3) N

Driver, vehicle, and roadway characteristics, laws and ordinances, traffic control devices, traffic engineering studies, and Transportation System Management measures. Prerequisite: CEE 372.

CEE 574 Highway Capacity. (3) N

Highway capacity for all functional classes of highways. Traffic signalization, including traffic studies, warrants, cycle length, timing, phasing, and coordination. Prerequisite: CEE 372.

CEE 575 Traffic Flow Theory and Safety Analysis. (3) N

Traffic flow theory; distributions, queuing, delay models, and car-following. Highway safety; accident records systems, accident analysis, identifying problem locations, and accident countermeasures. Prerequisite: CEE 573 or 574.

CEE 576 Airport Engineering. (3) N

Planning and design of airport facilities. Effect of aircraft characteristics, air traffic control procedures and aircraft demand for runway and passenger handling facilities, on-site selection, runway configuration, and terminal design. Prerequisite: CEE 372.

CEE 577 Urban Transportation Planning. (3) N

Application of land use parameters traffic generation theory, traffic distribution and assignment models, transit analysis, and economic factors to the solution of the urban transportation problem. Prerequisite: CEE 372.

Students enrolled in CEE 580, 590, 592, 599, 792, and 799 are required to attend graduate student seminars at the times shown in the Schedule of Classes. Each semester, every graduate student enrolled for more than eight semester hours is to enroll for at least one semester hour of CEE 592, 599, 792, or 799.

Department of Computer Science and Engineering

Stephen S. Yau

Chair

(GWC 206) 480/965-3190

Fax 480/965-2751

www.eas.asu.edu/~csdept

PROFESSORS

ASHCROFT, COLLOFELLO, FARIN, GOLSHANI, LEWIS,
NIELSON, J. URBAN, WOODFILL, YAU

ASSOCIATE PROFESSORS

BHATTCHARYA, DASGUPTA, DIETRICH, FALTZ, GHOSH,
HUEY, KAMBHAMPATI, LINDQUIST, MILLER, O'GRADY,
PANCHANATHAN, PHEANIS, ROCKWOOD,
SEN, S. URBAN

ASSISTANT PROFESSORS

BAZZI, CANDAN, CHALASANI, G. GANNOD,
RICHA, WAGNER

LECTURERS

DELIBERO, B. GANNOD, HOUSTON,
NAVABI, WHITEHOUSE

Computers have a significant impact on our daily lives, and this impact is likely to be even greater in the future as computer professionals continue to develop more powerful, smaller, faster, and less expensive computing systems. Computer science and computer engineering deal with the study, design, development, construction, and application of modern computing machinery. Other important topics include computing techniques and appropriate languages for general information processing, for scientific computation, for the recognition, storage, retrieval, and processing of data of all kinds, and for the automatic control and simulation of processes.

The curricula offered by the Department of Computer Science and Engineering prepare the student to be a participant in this rapidly changing area of technology by presenting in-depth treatments of the fundamentals of computer science and computer engineering. The department offers two undergraduate degrees: a B.S. degree in Computer Science and a B.S.E. degree in Computer Systems Engineering.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is required for the B.S. degree in Computer Science and the B.S.E. degree in Computer Systems Engineering. A minimum of 50 upper-division semester hours is required. In addition to the requirement for a cumulative GPA of 2.00 or higher, all computer science and computer systems engineering students must obtain a minimum grade of "C" in all CSE courses used for degree credit.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See “University Graduation Requirements,” page 81.

DEGREES

Computer Science—B.S.

The faculty in the Department of Computer Science and Engineering offer a B.S. degree that prepares the student for a career in computer science. A student pursuing a B.S. degree must complete the First-Year Composition requirement, the General Studies requirement, department degree requirements, the computer science core courses, a senior-level breadth requirement in the major, technical electives, and unrestricted electives. For more information, contact the department office, refer to the department Web site, or e-mail questions to cse.ugrad.desk@asu.edu.

The following list specifies departmental requirements for the B.S. degree in Computer Science.

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
————— <i>or</i> —————	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
————— <i>or</i> —————	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
—————	
Total	6

General Studies/Department Requirements

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i>	
HU/SB electives	18
<i>Literacy and Critical Inquiry</i>	
L1/L2 electives	6
<i>Natural Sciences/Basic Sciences</i>	
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
Science elective ³	4
—————	
Total	12
<i>Numeracy/Mathematics</i>	
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
MAT 243 Discrete Mathematical Structures	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 342 Linear Algebra	3
—————	
Total	21
General Studies/department requirement total	57

Computer Science Core

CSE 120 Digital Design Fundamentals	3
CSE 200 Concepts of Computer Science <i>N3</i>	3
CSE 210 Data Structures and Algorithms I <i>N3</i>	3

CSE 225 Assembly Language Programming and Microprocessors (Motorola) <i>N3</i>	4
or CSE 226 Assembly Language Programming and Microprocessors (Intel) <i>N3</i> (4)	
CSE 240 Introduction to Programming Languages	3
CSE 310 Data Structures and Algorithms II	3
CSE 330 Computer Organization and Architecture	3
CSE 340 Principles of Programming Languages	3
CSE 355 Introduction to Theoretical Computer Science	3
CSE 360 Introduction to Software Engineering	3
CSE 430 Operating Systems	3
—————	
Total computer science core	34
400-level CSE computer science breadth requirement	18
Technical electives ⁴	6
Unrestricted electives	7
—————	
Total	31
Degree requirements total	128

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ This elective may be satisfied by any physics courses requiring PHY 131 as a prerequisite or a laboratory science for science or engineering majors satisfying the S1 or S2 General Studies requirements (except PHS 110).

⁴ Each student must complete six hours of courses chosen from the computer science technical elective list and approved by the student’s advisor.

**Computer Science
Program of Study
Typical Four-Year Sequence
First Year**

First Semester	
CSE 200 Concepts of Computer Science <i>N3</i>	3
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
HU, SB, awareness area course ¹	3
Unrestricted elective	3
—————	
Total	16

Second Semester	
CSE 120 Digital Design Fundamentals	3
CSE 210 Data Structures and Algorithms I <i>N3</i>	3
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
Unrestricted elective	4
—————	
Total	17

Second Year

First Semester	
CSE 240 Introduction to Programming Languages	3
MAT 243 Discrete Mathematical Structures	3
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ²	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ²	1
HU, SB, awareness area course ¹	3
—————	
Total	17

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see “General Studies,” page 85. For graduation requirements, see “University Graduation Requirements,” page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see “Classification of Courses,” page 58.

Second Semester

CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
or CSE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
CSE 310 Data Structures and Algorithms II	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ³	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ³	1
HU, SB, awareness area course ¹	3
L1 elective	3
Total	17

Third Year**First Semester**

CSE 330 Computer Organization and Architecture	3
CSE 340 Principles of Programming Languages	3
MAT 342 Linear Algebra	3
HU, SB, awareness area course ¹	3
Laboratory science for engineering majors <i>S1/S2</i> ⁴	4
Total	16

Second Semester

CSE 355 Introduction to Theoretical Computer Science	3
CSE 360 Introduction to Software Engineering	3
CSE 430 Operating Systems	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
HU, SB, awareness area course ¹	3
Total	15

Fourth Year**First Semester**

400-level CSE computer science breadth electives	9
L2 elective	3
Technical elective	3
Total	15

Second Semester

400-level CSE computer science breadth electives	9
HU, SB, awareness area course ¹	3
Technical elective	3
Total	15

¹ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

² Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

³ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

⁴ This elective may be satisfied by any physics courses requiring PHY 131 as a prerequisite or any laboratory science for majors in the discipline and satisfying the S1 or S2 General Studies requirements (except PHS 110, PHY 101, 105, 111, or 112).

Computer Systems Engineering—B.S.E.

The Department of Computer Science and Engineering offers a B.S.E. degree that prepares the student for a career in computer systems engineering. This degree program provides training in both engineering and computer science. The following list specifies departmental requirements for the B.S.E. degree in Computer Systems Engineering.

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	

— or —

ENG 105 Advanced First-Year Composition (3)
Elective chosen with an advisor (3)

— or —

ENG 107 English for Foreign Students (3)
ENG 108 English for Foreign Students (3)

Total

General Studies/Department Requirements

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i>	
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
HU/SB electives	13
Total	16

Literacy and Critical Inquiry

CSE 423 Microcomputer System Hardware <i>L2</i>	3
ECE 300 Intermediate Engineering Design <i>L1</i>	3
Total	6

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
or CHM 116 General Chemistry <i>S1/S2</i> (4)	
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
PHY 361 Introductory Modern Physics	3
Total	15

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
MAT 243 Discrete Mathematical Structures	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
MAT 342 Linear Algebra	3
Total	28
General Studies/department requirement total	65

Engineering Core

CSE 200 Concepts of Computer Science <i>N3</i>	3
CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
ECE 210 Engineering Mechanics I: Statics	3
ECE 301 Electrical Networks I	4
ECE 334 Electronic Devices and Instrumentation	4
Total	18

Computer Science Core

CSE 120 Digital Design Fundamentals	3
CSE 210 Data Structures and Algorithms I <i>N3</i>	3
CSE 240 Introduction to Programming Languages	3
CSE 310 Data Structures and Algorithms II	3
CSE 330 Computer Organization and Architecture	3
CSE 340 Principles of Programming Languages	3
CSE 355 Introduction to Theoretical Computer Science	3
CSE 360 Introduction to Software Engineering	3
CSE 421 Microprocessor System Design I	4
CSE 422 Microprocessor System Design II	4
CSE 430 Operating Systems	3
Technical electives ³	4
Total	39

Degree requirement total.....128

- ¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.
- ² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.
- ³ Each student must complete four hours of courses chosen from the computer science technical elective list and approved by the student's advisor.

**Computer Systems Engineering
Program of Study
Typical Four-Year Sequence**

First Year

First Semester

CSE 200 Concepts of Computer Science <i>N3</i>	3
ECE 100 Introduction to Engineering Design <i>N3</i>	4
or CSE 120 Digital Design Fundamentals (3)	
ECN 111 Macroeconomic Principles <i>SB</i>	3
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>	4
<hr/>	
Total	17

Second Semester

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
CSE 120 Digital Design Fundamentals	3
or ECE 100 Introduction to Engineering Design <i>N3</i> (4)	
CSE 210 Data Structures and Algorithms I <i>N3</i>	3
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II <i>NI</i>	4
<hr/>	
Total	17

Second Year

First Semester

CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
MAT 243 Discrete Mathematical Structures	3
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
<hr/>	
Total	15

Second Semester

CSE 240 Introduction to Programming Languages	3
CSE 330 Computer Organization and Architecture	3
ECE 210 Engineering Mechanics I: Statics	3
MAT 274 Elementary Differential Equations <i>NI</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
<hr/>	
Total	16

Third Year

First Semester

CSE 310 Data Structures and Algorithms II	3
ECE 300 Intermediate Engineering Design <i>L1</i>	3
MAT 342 Linear Algebra	3
HU, SB, awareness area courses ³	7
<hr/>	
Total	16

Second Semester

CSE 340 Principles of Programming Languages	3
CSE 360 Introduction to Software Engineering	3
CSE 421 Microprocessor System Design I	4

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
HU, SB, awareness area course ³	3
<hr/>	
Total	16

Fourth Year

First Semester

CSE 355 Introduction to Theoretical Computer Science	3
CSE 422 Microprocessor System Design II	4
CSE 430 Operating Systems	3
ECE 301 Electrical Networks I	4
PHY 361 Introductory Modern Physics	3
<hr/>	
Total	17

Second Semester

CSE 423 Microcomputer System Hardware <i>L2</i>	3
ECE 334 Electronic Devices and Instrumentation	4
HU, SB, awareness area course ³	3
Technical electives	4
<hr/>	
Total	14

- ¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.
- ² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.
- ³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

COMPUTER SCIENCE AND ENGINEERING (CSE)

CSE 100 Principles of Programming. (3) F, S, SS

Concepts of problem solving, algorithm design, structured programming, fundamental algorithms and techniques, and computer systems concepts. Social and ethical responsibility. Prerequisite: MAT 170. *General Studies: N3.*

CSE 120 Digital Design Fundamentals. (3) F, S, SS

Number systems, conversion methods, binary and complement arithmetic, Boolean algebra, circuit minimization, ROMs, PLAs, flipflops, synchronous sequential circuits. Lecture, lab. Cross-listed as EEE 120. Credit is allowed for only CSE 120 or EEE 120. Prerequisite: computer literacy.

CSE 180 Computer Literacy. (3) F, S, SS

Introduction to personal computer operations and their place in society. Problem-solving approaches using databases, spreadsheets, and word processing. May be taken for credit on either Windows or Macintosh, but not both. Lecture, demonstration. Prerequisite: nonmajor. *General Studies: N3.*

CSE 181 Applied Problem Solving with Visual BASIC. (3) F, S, SS

Introduction of systematic definition of problems, solution formulation, and method validation. Computer solution using Visual BASIC required for projects. Lecture, lab. Prerequisites: MAT 117; nonmajor. *General Studies: N3.*

CSE 183 Applied Problem Solving with FORTRAN. (3) F

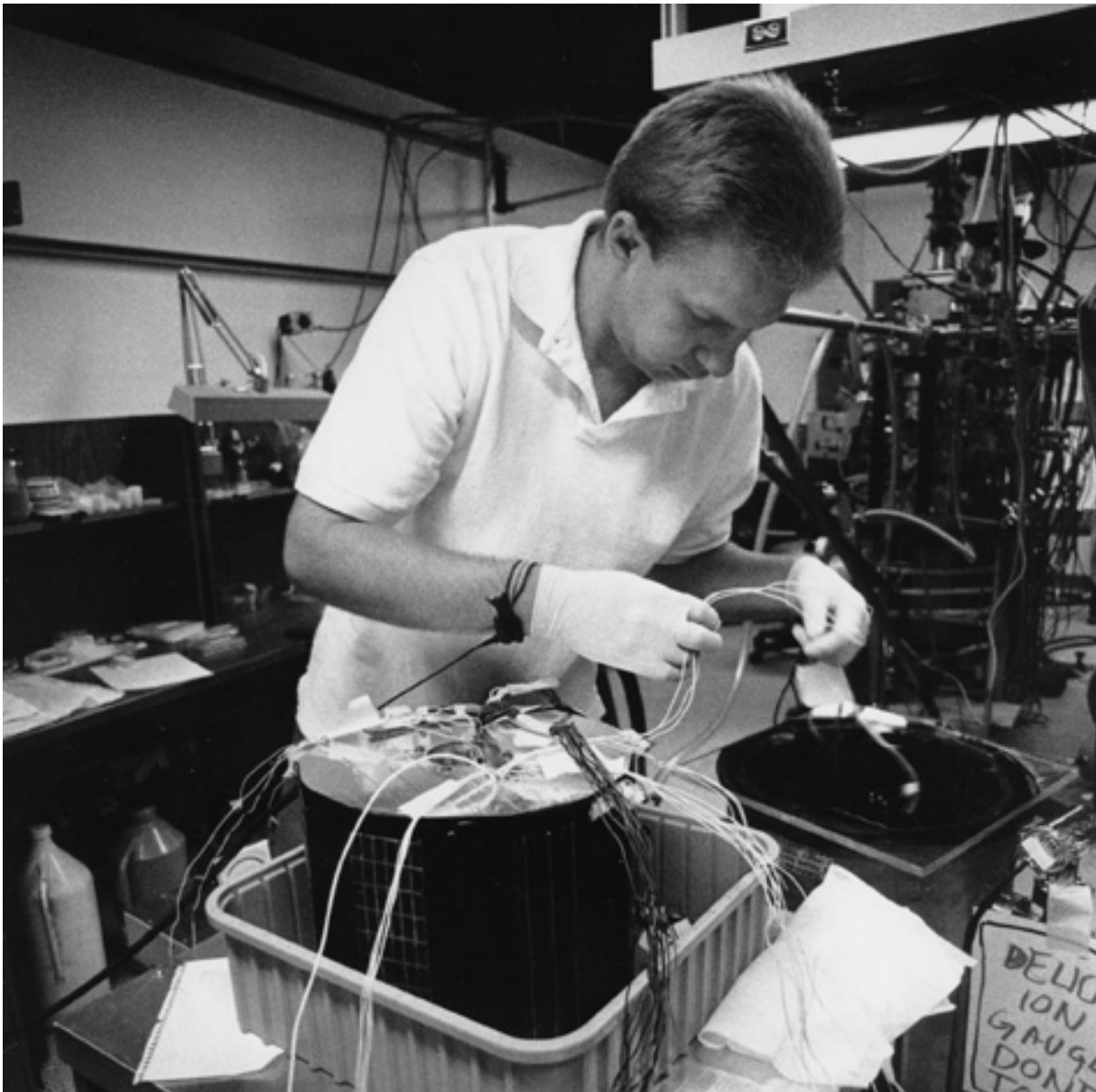
A human-oriented, systems approach to problem definition, formulation, and solution using FORTRAN. Computer solution required for projects. Prerequisites: MAT 170; nonmajor. *General Studies: N3.*

CSE 185 Internet and the World Wide Web. (3) F, S

Fundamental Internet concepts, World Wide Web browsing, publishing, searching, advanced Internet productivity tools.

CSE 200 Concepts of Computer Science. (3) F, S, SS

Overview of algorithms, architecture, languages, operating systems, theory. Problem solving with a high level language (C++). Lecture, lab. Prerequisite: one year of high school programming with a structured language (C++ preferred) or CSE 100. *General Studies: N3.*



Graduate student Joel Rademacher prepares a student-built satellite for vacuum testing.

Jeff Havir photo

CSE 210 Data Structures and Algorithms I. (3) F, S, SS

Object oriented design, static and dynamic data structures (strings, stacks, queues, binary trees), recursion, and searching and sorting. Professional responsibility. Prerequisite: CSE 200. *General Studies:* N3.

CSE 225 Assembly Language Programming and Microprocessors (Motorola). (4) F, S, SS

Assembly language programming, including input/output programming and exception/interrupt handling. Register-level computer organization, I/O interfaces, assemblers, and linkers. Motorola-based assignments. Lecture, lab. Cross-listed as EEE 225. Credit is allowed for only CSE 225 or EEE 225. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

CSE 226 Assembly Language Programming and Microprocessors (Intel). (4) F, S

CPU/Memory/peripheral device interfaces and programming. System buses, interrupts, serial and parallel I/O, DMA, coprocessors. Intel-based assignments. Lecture, lab. Cross-listed as EEE 226. Credit is allowed for only CSE 226 or EEE 226. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

CSE 240 Introduction to Programming Languages. (3) F, S, SS

Introduction to the procedural (Ada), applicative (LISP), and declarative (Prolog) languages. Lecture, lab. Prerequisite: CSE 210.

CSE 310 Data Structures and Algorithms II. (3) F, S, SS

Advanced data structures and algorithms, including stacks, queues, trees (B, B+, AVL), and graphs. Searching for graphs, hashing, external sorting. Lecture, lab. Prerequisites: CSE 210; MAT 243.

CSE 330 Computer Organization and Architecture. (3) F, S, SS

Instruction set architecture, processor performance and design; data-path, control (hardwired, microprogrammed), pipelining, input/output. Memory organization with cache, virtual memory. Prerequisite: CSE/EEE 225 or 226.

CSE 340 Principles of Programming Languages. (3) F, S, SS

Introduction to language design and implementation. Parallel, machine-dependent and declarative features; type theory; specification, recognition, translation, run-time management. Prerequisites: CSE 240, 310; CSE/EEE 225 (or 226).

CSE 355 Introduction to Theoretical Computer Science. (3) F, S

Introduction to formal language theory and automata, Turing machines, decidability/undecidability, recursive function theory, and introduction to complexity theory. Prerequisite: CSE 310.

CSE 360 Introduction to Software Engineering. (3) F, S, SS

Software life cycle models; project management, team development environments and methodologies; software architectures; quality assurance and standards; legal, ethical issues. Prerequisites: CSE 210, 240.

CSE 408 Multimedia Information Systems. (3) F

Design, use, and applications of multimedia systems. An introduction to acquisition, compression, storage, retrieval, and presentation of data from different media such as images, text, voice, and alphanumeric. Prerequisite: CSE 310.

CSE 412 Database Management. (3) F, S

Introduction to DBMS concepts. Data models and languages. Relational database theory. Database security/integrity and concurrency. Prerequisite: CSE 310.

CSE 420 Computer Architecture I. (3) S

Computer architecture. Performance versus cost trade-offs. Instruction set design. Basic processor implementation and pipelining. Prerequisite: CSE 330.

CSE 421 Microprocessor System Design I. (4) F, S

Assembly-language programming and logical hardware design of systems using 8-bit microprocessors and microcontrollers. Fundamental concepts of digital system design. Reliability and social, legal implications. Lecture, lab. Prerequisite: CSE/EEE 225.

CSE 422 Microprocessor System Design II. (4) F, S

Design of microcomputer systems using contemporary logic and microcomputer system components. Requires assembly language programming. Prerequisite: CSE 421.

CSE 423 Microcomputer System Hardware. (3) S

Information and techniques presented in CSE 422 are used to develop the hardware design of a multiprocessor, multiprogramming, microprocessor-based system. Prerequisite: CSE 422. *General Studies:* L2.

CSE 428 Computer-Aided Processes. (3) A

Hardware and software considerations for computerized manufacturing systems. Specific concentration on automatic inspection, numerical control, robotics, and integrated manufacturing systems. Prerequisite: CSE 330.

CSE 430 Operating Systems. (3) F, S

Operating system structure and services, processor scheduling, concurrent processes, synchronization techniques, memory management, virtual memory, input/output, storage management, and file systems. Prerequisites: CSE 330, 340.

CSE 434 Computer Networks. (3) F, S

Cryptography fundamentals; data compression; error handling; flow control; multihop routing; network protocol algorithms; network reliability, timing, security; physical layer basics. Prerequisite: CSE 330.

CSE 438 Systems Programming. (3) A

Design and implementation of systems programs, including text editors, file utilities, monitors, assemblers, relocating linking loaders, I/O handlers, and schedulers. Prerequisite: CSE 421 or instructor approval. *General Studies:* L2.

CSE 440 Compiler Construction I. (3) F

Introduction to programming language implementation. Implementation strategies such as compilation, interpretation, and translation. Major compilation phases such as lexical analysis, semantic analysis, optimization, and code generation. Prerequisites: CSE 340, 355.

CSE 445 Distributed Computing with Java and CORBA. (3) F, S

Technologies for developing software components. Client-server computing with sockets and distributed objects. Dynamic interface discovery and invocation. Lecture, projects. Prerequisite: CSE 310 or instructor approval.

CSE 446 Client-Server User Interfaces. (3) S

Client-server model and its use in creating and managing window interfaces. Toolkits and libraries including X11, Microsoft Foundation Classes, and Java Abstract Window Toolkit. Lecture, projects. Prerequisite: CSE 310 or instructor approval.

CSE 450 Design and Analysis of Algorithms. (3) F

Design and analysis of computer algorithms using analytical and empirical methods; complexity measures, design methodologies, and survey of important algorithms. Prerequisite: CSE 310.

CSE 457 Theory of Formal Languages. (3) A

Theory of grammar, methods of syntactic analysis and specification, types of artificial languages, relationship between formal languages, and automata. Prerequisite: CSE 355.

CSE 459 Logic for Computing Scientists I. (3) F

Propositional logic, syntax and semantics, proof theory versus model theory, soundness, consistency and completeness, first order logic, logical theories, automated theorem proving, ground resolution, pattern matching unification and resolution, Dijkstras logic, proof obligations, and program proving. Prerequisite: CSE 355.

CSE 461 Software Engineering Project I. (3) F

First of two-course software design sequence. Development planning, management; process modeling; incremental and team development using CASE tools. Lecture, lab. Prerequisite: CSE 360.

CSE 462 Software Engineering Project II. (3) S

Second of two-course software design sequence. Process, product assessment and improvement; incremental and team development using CASE tools. Lecture, lab. Prerequisite: CSE 461.

CSE 470 Computer Graphics. (3) F, S

Display devices, data structures, transformations, interactive graphics, 3-dimensional graphics, and hidden line problem. Prerequisites: CSE 310; MAT 342.

CSE 471 Introduction to Artificial Intelligence. (3) F, S

State space search, heuristic search, games, knowledge representation techniques, expert systems, and automated reasoning. Prerequisites: CSE 240, 310.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

CSE 473 Nonprocedural Programming Languages. (3) S

Functional and logic programming using languages like Lucid and Prolog. Typical applications would be a Screen Editor and an Expert System. Prerequisite: CSE 355.

CSE 476 Introduction to Natural Language Processing. (3) F

Principles of computational linguistics, formal syntax, and semantics, as applied to the design of software with natural (human) language I/O. Prerequisite: CSE 310 or instructor approval.

CSE 477 Introduction to Computer-Aided Geometric Design. (3) F, S

Introduction to parametric curves and surfaces, Bezier and B-spline interpolation, and approximation techniques. Prerequisites: CSE 210, 470; MAT 342.

CSE 507 Virtual Reality Systems. (3) S

Computer generated 3D environments, simulation of reality, spatial presence of virtual objects, technologies of immersion, tracking systems. Lecture, lab. Prerequisite: CSE 408 or 470 or 508 or instructor approval.

CSE 508 Digital Image Processing. (3) S

Digital image fundamentals, image transforms, image enhancement and restoration techniques, image encoding, and segmentation methods. Prerequisite: EEE 303 or instructor approval.

CSE 510 Advanced Database Management. (3) F, S

Advanced data modeling, deductive databases, object-oriented databases, distributed and multidatabase systems; emerging database technologies. Prerequisite: CSE 412.

CSE 512 Distributed Databases. (3) A

Fragmentation design. Query optimization. Distributed joins. Concurrency control. Distributed deadlock detection. Prerequisite: CSE 510.

CSE 513 Deductive Databases. (3) F

Logic as a data model. Query optimization emphasizing the top-down and bottom-up evaluation of declarative rules. Prerequisite: CSE 510.

CSE 514 Object-Oriented Database Systems. (3) A

Object-oriented data modeling, database and language integration, object algebras, extensibility, transactions, object managers, versioning/configuration, active data, nonstandard applications. Research seminar. Prerequisite: CSE 510.

CSE 517 Hardware Design Languages. (3) F

Introduction to hardware design languages. Modeling concepts for specification, simulation, and synthesis. Prerequisite: CSE 423 or EEE 425 or instructor approval.

CSE 518 Synthesis with Hardware Design Languages. (3) N

Modeling VLSI design in hardware design languages for synthesis. Transformation of language-based designs to physical layout. Application of synthesis tools. Prerequisite: CSE 517.

CSE 520 Computer Architecture II. (3) F

Computer architecture description languages, computer arithmetic, memory-hierarchy design, parallel, vector, and multiprocessors, and input/output. Prerequisites: CSE 420, 430.

CSE 521 Microprocessor Applications. (4) S

Microprocessor technology and its application to the design of practical digital systems. Hardware, assembly language programming, and interfacing of microprocessor-based systems. Lecture, lab. Prerequisite: CSE 421.

CSE 523 Microcomputer Systems Software. (3) F

Developing system software for a multiprocessor, multiprogramming, microprocessor-based system using information and techniques presented in CSE 421, 422. Prerequisite: CSE 422.

CSE 526 Parallel Processing. (3) N

Real and apparent concurrency. Hardware organization of multiprocessors, multiple computer systems, scientific attached processors, and other parallel systems. Prerequisite: CSE 330 or 423.

CSE 530 Operating System Internals. (3) F

Implementation of process management and synchronization, system call and interrupt handling, memory management, device drivers and file systems in UNIX. Prerequisites: CSE 430; knowledge of C language.

CSE 531 Distributed and Multiprocessor Operating Systems. (3) N

Distributed systems architecture, remote file access, message-based systems, object-based systems, client/server paradigms, distributed algorithms, replication and consistency, and multiprocessor operating systems. Prerequisite: CSE 530 or instructor approval.

CSE 532 Advanced Operating System Internals. (3) F

Memory, processor, process and communication management, and concurrency control in the Windows NT multiprocessor and distributed operating system kernels and servers. Prerequisite: CSE 530 or instructor approval.

CSE 534 Advanced Computer Networks. (3) F

Advanced network protocols and infrastructure, applications of high-performance networks to distributed systems, high-performance computing and multimedia domains, special features of networks. Prerequisite: CSE 434.

CSE 536 Theory of Operating Systems. (3) S

Protection. Communication and synchronization in distributed systems, distributed file systems, deadlock theory, virtual memory theory, and uniprocessor and multiprocessor thread management. Prerequisite: CSE 430.

CSE 540 Compiler Construction II. (3) S

Formal parsing strategies, optimization techniques, code generation, extensibility and transportability considerations, and recent developments. Prerequisite: CSE 440.

CSE 545 Programming Language Design. (3) N

Language constructs, extensibility and abstractions, and runtime support. Language design process. Prerequisite: CSE 440.

CSE 550 Combinatorial Algorithms and Intractability. (3) N

Combinatorial algorithms, nondeterministic algorithms, classes P and NP, NP-hard and NP-complete problems, and intractability. Design techniques for fast combinatorial algorithms. Prerequisite: CSE 450.

CSE 555 Automata Theory. (3) N

Finite state machines, pushdown automata, linear bounded automata, Turing machines, register machines, rams, and rasps; relationships to computability and formal languages. Prerequisite: CSE 355.

CSE 556 Expert Systems. (3) S

Knowledge acquisition and representation, rule-based systems, frame-based systems, validation of knowledge bases, inexact reasoning, and expert database systems. Prerequisite: CSE 471.

CSE 560 Software Engineering. (3) F, S

Software engineering foundations, formal representations in the software process; use of formalisms in creating a measured and structured working environment. Lecture, lab. Prerequisite: CSE 360.

CSE 562 Parallel and Distributed Software Engineering. (3) A

Software engineering characteristics particular to parallel and distributed systems. Tools and techniques to support software engineering involving parallel processing and distributed systems. Prerequisite: CSE 560.

CSE 563 Software Requirements and Specification. (3) A

Examination of the definitional stage of software development; analysis of specification representations, formal methods, and techniques emphasizing important application issues. Prerequisite: CSE 560.

CSE 564 Software Design. (3) A

Examination of software design issues and techniques. Includes a survey of design representations and a comparison of design methods. Prerequisite: CSE 560.

CSE 565 Software Verification, Validation, and Testing. (3) A

Test planning, requirements-based and code-based testing techniques, tools, reliability models, and statistical testing. Prerequisite: CSE 560.

CSE 566 Software Project, Process, and Quality Management. (3) A

Project management, risk management, configuration management, quality management, and simulated project management experiences. Prerequisite: CSE 560.

CSE 570 Advanced Computer Graphics I. (3) F

Hidden surface algorithms, lighting models, and shading techniques. User interface design. Animation techniques. Fractals and stochastic models. Raster algorithms. Prerequisite: CSE 470.

CSE 571 Artificial Intelligence. (3) S

Definitions of intelligence, computer problem solving, game playing, pattern recognition, theorem proving, and semantic information processing; evolutionary systems; heuristic programming. Prerequisite: CSE 471.

CSE 573 Advanced Computer Graphics II. (3) S

Modeling of natural phenomena: terrain, clouds, fire, water, and trees. Particle systems, deformation of solids, antialiasing, and volume visualization. Lecture, lab. Prerequisite: CSE 470.

CSE 574 Planning and Learning Methods in AI. (3) F

Reasoning about time and action, plan synthesis and execution, improving planning performance, applications to manufacturing intelligent agents. Prerequisite: CSE 471 or equivalent.

CSE 575 Decision-Making Strategies in AI. (3) S

Automatic knowledge acquisition, automatic analysis/synthesis of strategies, distributed planning/problem solving, causal modeling, predictive human-machine environments. Prerequisite: CSE 471 or 571 or equivalent.

CSE 576 Topics in Natural Language Processing. (3) S

Comparative parsing strategies, scoping and reference problems, nonfirst-order logical semantic representations, and discourse structure. Prerequisite: CSE 476 or instructor approval.

CSE 577 Advanced Computer-Aided Geometric Design I. (3) F

General interpolation; review of curve interpolation and approximation; spline curves; visual smoothness of curves; parameterization of curves; introduction to surface interpolation and approximation. Prerequisites: CSE 470 and 477 or instructor approval.

CSE 578 Advanced Computer-Aided Geometric Design II. (3) S

Coons patches and Bezier patches; triangular patches; arbitrarily located data methods; geometry processing of surfaces; higher dimensional surfaces. Prerequisites: CSE 470 and 477 or instructor approval.

CSE 579 NURBs: Nonuniform Rational B-Splines. (3) S

Projective geometry, NURBs-based modeling, basic theory of conics and rational Bezier curves, rational B-splines, surfaces, rational surfaces, stereographic maps, quadrics, IGES data specification. Prerequisites: CSE 470, 477.

Department of Electrical Engineering

Stephen M. Goodnick
Chair

(ENGR 552) 480/965-3424
www.eas.asu.edu/ee

REGENTS' PROFESSORS

BALANIS, FERRY

PROFESSORS

ALLSTOT, BACKUS, CROUCH, DeMASSA,
EL-GHAZALY, GOODNICK, GORUR, HEYDT, HIGGINS,
KARADY, KOZICKI, PALAIS, PAN, ROEDEL, SADOWSKY,
SCHRODER, SPANIAS, THORNTON

ASSOCIATE PROFESSORS

ABERLE, ALLEE, BIRD, CHAKRABARTI, COCHRAN,
EL-SHARAWY, GREENEICH, GRONDIN, HOLBERT,
MORRELL, RODRIGUEZ, SHEN, SI, SKROMME,
TSAKALIS, TYLAVSKY, ZHANG

ASSISTANT PROFESSORS

CAPONE, DUMAN, KARAM,
VASILESKA-KAFEDZISKA, YAZDI

The professional activities of electrical engineers directly affect the lives of most of the world's population every day. They are responsible for the design and development of radio and television transmitters and receivers, telephone networks and switching systems, computer systems, and

electric power generation and distribution. Within the broad scope of these systems, the electrical engineer is concerned with a challenging and diverse array of design and development problems.

Electrical engineers design minuscule semiconductor integrated circuits that contain many thousands of elementary devices. They design systems for automatically controlling mechanical devices and a variety of processes. They are responsible for the design of satellite communication links as well as patient monitoring systems for hospitals. The development of the microprocessor has expanded the opportunities for electrical engineers to improve the design of familiar products since these devices are now incorporated in automobiles, consumer and office products, entertainment systems, and a vast variety of test and measurement instruments and machine tools.

Students who earn a B.S.E. degree in Electrical Engineering will be involved in a variety of electrical and electronic problems in the course of their careers. To ensure the necessary breadth of knowledge, the Electrical Engineering curriculum includes basic (core) engineering courses and courses in networks and electronic circuits, electromagnetic fields and waves, microprocessors, communication and control systems, solid-state electronics, electrical power systems, and other specialty courses.

ELECTRICAL ENGINEERING—B.S.E.

The goal of the Electrical Engineering undergraduate program is to prepare the graduates for entry-level positions as electrical engineers for the broad range of opportunities available in industrial, commercial, and governmental organizations, and to prepare the graduates for continued learning experiences either in a formal graduate program or in continuing education applications.

The curriculum in Electrical Engineering builds upon the base provided by the engineering core. Beyond the engineering core, the curriculum includes a number of required electrical engineering and technical elective courses. Approved technical elective courses serve to provide students with an opportunity either to broaden their background in electrical engineering or to study, in greater depth, technical subjects in which they have special interests. Successful completion of the curriculum leaves the student prepared to embark on a career in electrical engineering or to pursue advanced education in graduate school.

The engineering design experience is structured around three backbone courses employing engineering teams: ECE 100 Introduction to Engineering Design (freshman year), ECE 300 Intermediate Engineering Design (junior year), and EEE 490 Senior Design Laboratory. The integrated experience is strengthened with required courses, EEE 120 Digital Design Fundamentals, EEE 225/226 Assembly Language Programming and Microprocessors, EEE 303 Signals and Systems, and EEE 360 Energy Conversion and Transport. Students focus on design pertaining to specific electrical engineering areas in their senior technical electives before the culminating, capstone design experience in EEE 490.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Electrical Engineering. A minimum of 50 upper-division semester hours is required.

GRADUATION REQUIREMENTS

A student must earn a grade of "C" or higher in the mathematics and physics courses listed in the program of study. The student must also have an overall GPA of at least 2.00 for the following group of courses: CSE 100; ECE 300, 301, 334, 352; all courses with an EEE prefix; and all other courses used as technical electives.

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 81.

COURSE REQUIREMENTS

The specific course requirements for the B.S.E. degree in Electrical Engineering follow.

First-Year Composition¹

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
————— <i>or</i> —————	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
————— <i>or</i> —————	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
HU courses	6–10
SB courses	3–7
Minimum total	16

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L1</i>	3
EEE 490 Senior Design Laboratory <i>L2</i>	3
Total	6

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
or CHM 116 General Chemistry <i>S1/S2</i> (4)	
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ²	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ²	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ³	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ³	1
PHY 241 University Physics III	3
Total	15

Numeracy and Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
MAT 342 Linear Algebra	3

MAT 362 Advanced Mathematics for Engineers and Scientists I	3
Total	25
General Studies/school requirements total	62

Engineering Core

ECE 301 Electrical Networks I	4
ECE 314 Engineering Mechanics	4
ECE 334 Electronic Devices and Instrumentation	4
ECE 352 Properties of Electronic Materials	4
EEE 225 Assembly Language Programming and Microprocessors (Motorola)	4
or EEE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
Total	20

¹ A minimum grade of "C" is required.

² Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

³ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

Electrical Engineering Major

The following courses are required to fulfill the Electrical Engineering major:

CSE 100 Principles of Programming <i>N3</i>	3
EEE 120 Digital Design Fundamentals	3
EEE 302 Electrical Networks II	3
EEE 303 Signals and Systems	3
EEE 340 Electromagnetic Engineering I	4
EEE 350 Random Signal Analysis	3
EEE 360 Energy Conversion and Transport	4
Total	23

Technical Electives in Electrical Engineering

The program in Electrical Engineering requires a total of 17 hours of technical electives. With department approval, a maximum of two technical electives may be taken outside electrical engineering. Qualified students may choose from approved courses in business, engineering, mathematics, and the sciences at or above the 300-level, including graduate courses. Students must have a GPA of not less than 3.00 and approval of the dean to enroll in EEE graduate-level courses. To ensure breadth of knowledge, students *must* select courses from at least three of the following six areas. In addition, to ensure depth, two courses must be taken in one area.

Communications

EEE 407 Digital Signal Processing	4
EEE 455 Communication Systems	4
EEE 459 Data Communication Systems	3

Control

EEE 480 Feedback Systems	4
EEE 482 Introduction to State Space Methods	3

Electromagnetics

EEE 440 Electromagnetic Engineering II	4
EEE 443 Antennas	3
EEE 445 Microwaves	4
EEE 448 Fiber Optics	4

Electronic Circuits

EEE 405 Filter Design	3
EEE 425 Digital Systems and Circuits	4
EEE 433 Analog Integrated Circuits	3

Power Systems

EEE 460 Nuclear Concepts for the 21st Century	3
EEE 463 Electrical Power Plant	3

EEE 470 Electric Power Devices	3
EEE 471 Power System Analysis	3
EEE 473 Electrical Machinery	3
Solid-State Electronics	
EEE 434 Quantum Mechanics for Engineers	3
EEE 435 Microelectronics	3
EEE 436 Fundamentals of Solid-State Devices	3
EEE 437 Optoelectronics	3
EEE 439 Semiconductor Facilities and Cleanroom Practices	3

With department approval Computer Science and Engineering courses at or above the 300 level may be substituted for one of the above areas.

**Electrical Engineering
Program of Study
Typical Four-Year Sequence**

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>S1/S2</i>	4
or CHM 116 General Chemistry <i>S1/S2</i> (4)	
ECE 100 Introduction to Engineering Design <i>N3</i>	4
or EEE 120 Digital Design Fundamentals (3)	
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
Total	15

Second Semester

EEE 120 Digital Design Fundamentals	3
or ECE 100 Introduction to Engineering Design <i>N3</i> (4)	
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
Total	14

Second Year

First Semester

CSE 100 Principles of Programming <i>N3</i>	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Macroeconomic Principles <i>SB</i> (3)	
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
Total	17

Second Semester

ECE 301 Electrical Networks I	4
EEE 225 Assembly Language Programming and Microprocessors (Motorola)	4
or EEE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
MAT 362 Advanced Mathematics for Engineers and Scientists I	3
PHY 241 University Physics III	3
HU, SB, and awareness area course ³	3
Total	17

Third Year

First Semester

ECE 300 Intermediate Engineering Design <i>L1</i>	3
EEE 302 Electrical Networks II	3
EEE 340 Electromagnetic Engineering I	4
MAT 342 Linear Algebra	3
HU, SB, and awareness area course(s) ³	4
Total	17

Second Semester

ECE 334 Electronic Devices and Instrumentation	4
ECE 352 Properties of Electronic Materials	4
EEE 303 Signals and Systems	3
EEE 360 Energy Conversion and Transport	4
Total	15

Fourth Year

First Semester

ECE 314 Engineering Mechanics	4
EEE 350 Random Signal Analysis	3
HU, SB, and awareness area course ³	3
Technical electives	7
Total	17

Second Semester

EEE 490 Senior Design Laboratory <i>L2</i>	3
HU, SB, and awareness area course ³	3
Technical electives	10
Total	16

- ¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.
- ² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.
- ³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.

ELECTRICAL ENGINEERING (EEE)

EEE 120 Digital Design Fundamentals. (3) F, S, SS
Number systems, conversion methods, binary and complement arithmetic, Boolean algebra, circuit minimization, ROMs, PLAs, flipflops, synchronous sequential circuits. Lecture, lab. Cross-listed as CSE 120. Credit is allowed for only CSE 120 or EEE 120. Prerequisite: computer literacy.

EEE 225 Assembly Language Programming and Microprocessors (Motorola). (4) F, S, SS
Assembly language programming, including input/output programming and exception/interrupt handling. Register-level computer organization, I/O interfaces, assemblers, and linkers. Motorola-based assignments. Lecture, lab. Cross-listed as CSE 225. Credit is allowed for only CSE 225 or EEE 225. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

EEE 226 Assembly Language Programming and Microprocessors (Intel). (4) F, S
CPU/memory/peripheral device interfaces and programming. System buses, interrupts, serial and parallel I/O, DMA, coprocessors. Intel-based assignments. Lecture, lab. Cross-listed as CSE 226. Credit is allowed for only CSE 226 or EEE 226. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

EEE 302 Electrical Networks II. (3) F, S, SS
Analysis of linear and nonlinear networks. Analytical and numerical methods. Prerequisite: ECE 301. Pre- or corequisite: MAT 362.

EEE 303 Signals and Systems. (3) F, S, SS
Introduction to continuous and discrete time signal and system analysis, linear systems, Fourier, and z-transforms. Prerequisite: EEE 302. Pre- or corequisite: MAT 342.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

EEE 340 Electromagnetic Engineering I. (4) F, S, SS

Static and time varying vector fields; boundary value problems; dielectric and magnetic materials; Maxwell's equations; boundary conditions. Prerequisites: MAT 362; PHY 131, 132.

EEE 350 Random Signal Analysis. (3) F, S

Probabilistic and statistical analysis as applied to electrical signals and systems. Pre- or corequisite: EEE 303 or MAE 317.

EEE 360 Energy Conversion and Transport. (4) F, S

Three phase circuits. Energy supply systems. Magnetic circuit analysis, synchronous generators, transformers, induction and DC machines. Transmission Line Modeling and Design. Lecture, lab. Prerequisite: EEE 302.

EEE 405 Filter Design. (3) F

Principles of active and passive analog filter design, frequency domain approximations, sensitivity and synthesis of filters. Prerequisite: EEE 303.

EEE 407 Digital Signal Processing. (4) F

Time and frequency domain analysis, difference equations, z-transform, FIR and IIR Digital Filter Design, Discrete Fourier Transform, FFT, and random sequences. Lecture, lab. Prerequisites: EEE 303; MAT 342.

EEE 425 Digital Systems and Circuits. (4) F, S

Digital logic gate analysis and design. Propagation delay times, fan out, power dissipation, noise margins. Design of MOS and bipolar logic families, including NMOS, CMOS, standard and advanced TTL, ECL, and BiCMOS. Inverter, combinational and sequential logic circuit design, MOS memories, VLSI circuits. Computer simulations using PSPICE. Lecture, lab. Prerequisite: ECE 334.

EEE 433 Analog Integrated Circuits. (3) S

Analysis, design, and applications of modern analog circuits using integrated bipolar and field effect transistor technologies. Prerequisite: ECE 334.

EEE 434 Quantum Mechanics for Engineers. (3) F

Angular momentum, wave packets, Schroedinger wave equation, probability, problems in one dimension, principles of wave mechanics, scattering, tunneling, central forces, angular momentum, hydrogen atom, perturbation theory, variational techniques. Prerequisites: ECE 352; EEE 340.

EEE 435 Microelectronics. (3) S

Practice of solid-state device fabrication techniques, including thin film and integrated circuit fabrication principles. Lecture, lab. Pre- or corequisite: EEE 436.

EEE 436 Fundamentals of Solid-State Devices. (3) F, S

Semiconductor fundamentals, pn junctions, metal-semiconductor contacts, metal-oxide-semiconductor capacitors and field-effect transistors, bipolar junction transistors. Prerequisite: ECE 352.

EEE 437 Optoelectronics. (3) N

Basic operating principles of various types of optoelectronic devices which play important roles in commercial and communication electronics; light emitting diodes, injection lasers, and photodetectors. Prerequisite: EEE 436.

EEE 439 Semiconductor Facilities and Cleanroom Practices. (3) F

Microcontamination, controlled environments, cleanroom layout and systems, modeling, codes and legislation, ultrapure water, production materials, personnel and operations, hazard management, advanced concepts. Prerequisite: EEE 435 or instructor approval.

EEE 440 Electromagnetic Engineering II. (4) F, S

Second half of an introductory course in electromagnetic theory and its application in electrical engineering. Analytical and numerical solution of boundary value problems. Advanced transmission lines; waveguides; antennas; radiation and scattering. Lecture, lab. Prerequisite: EEE 340 or equivalent.

EEE 443 Antennas. (3) S

Fundamental parameters; engineering principles and radiation integrals; linear wire antennas; loops and arrays; numerical computations; measurements. Prerequisite: EEE 340 or equivalent.

EEE 445 Microwaves. (4) F

Waveguides; circuit theory for waveguiding systems; microwave devices, systems, and energy sources; striplines and microstrips; impedance matching transformers; measurements. Lecture, lab. Prerequisite: EEE 340 or equivalent.

EEE 448 Fiber Optics. (4) F

Principles of fiber-optic communications. Lecture, lab. Prerequisites: EEE 303, 340.

EEE 455 Communication Systems. (4) F, S

Signal analysis techniques applied to the operation of electrical communication systems. An introduction to and overview of modern digital and analog communications. Lecture, lab. Prerequisite: EEE 350.

EEE 459 Data Communication Systems. (3) S

System characteristics. Communications media. Communication codes. Data validity checking. Line protocols, terminals, and system configurations. Examples. Prerequisite: EEE 303.

EEE 460 Nuclear Concepts for the 21st Century. (3) N

Radiation interactions, damage, dose, and instrumentation. Cosmic rays, satellite effects; soft errors; transmutation doping. Fission reactors, nuclear power. TMI, Chernobyl. Radioactive waste. Prerequisite: PHY 241 or 361.

EEE 463 Electrical Power Plant. (3) F

Nuclear, fossil, and solar energy sources. Analysis and design of steam supply systems, electrical generating systems, and auxiliary systems. Power plant efficiency and operation. Prerequisites: ECE 301, 340 (or PHY 241).

EEE 470 Electric Power Devices. (3) F

Analysis of devices used for short circuit protection, including circuit breakers, relays, and current and voltage transducers. Protection against switching and lightning over voltages. Insulation coordination. Prerequisite: EEE 360.

EEE 471 Power System Analysis. (3) S

Review of transmission line parameter calculation. Zero sequence impedance, symmetrical components for fault analysis, short circuit calculation, review of power flow analysis, power system stability, and power system control concepts. Prerequisite: EEE 360.

EEE 473 Electrical Machinery. (3) F

Operating principles, constructional details, and design aspects of conventional DC and AC machines, transformers and machines used in computer disc drives, printers, wrist watches, and automobiles. Prerequisite: EEE 360.

EEE 480 Feedback Systems. (4) F, S

Analysis and design of linear feedback systems. Frequency response and root locus techniques, series compensation, and state variable feedback. Lecture, lab. Prerequisite: EEE 303.

EEE 482 Introduction to State Space Methods. (3) F

Discrete and continuous systems in state space form controllability, stability, and pole placement. Observability and observers. Pre- or corequisite: EEE 480.

EEE 490 Senior Design Laboratory. (3) F, S

Project-oriented laboratory. Each student must complete one or more design projects during the semester. Lecture, lab. Prerequisites: ECE 300, 334; EEE 303; senior status. *General Studies: L2.*

EEE 506 Digital Spectral Analysis. (3) S

Principles and applications of digital spectral analysis, least squares, random sequences, parametric, and nonparametric methods for spectral estimation. Prerequisites: EEE 407, 554.

EEE 507 Multidimensional Signal Processing. (3) F

Processing and representation of multidimensional signals. Design of systems for processing multidimensional data. Introduction to image and array processing issues. Prerequisite: EEE 407 or instructor approval.

EEE 508 Digital Image Processing and Compression. (3) S

Fundamentals of digital image perception, representation, processing, and compression. Emphasis on image coding techniques. Signals include still pictures and motion video. Prerequisites: EEE 350 and 407 or equivalents.

EEE 511 Artificial Neural Computation Systems. (3) F

Networks for computation, learning function representations from data, learning algorithms and analysis, function approximation and information representation by networks, applications in control systems and signal analysis. Prerequisite: instructor approval.

EEE 523 Advanced Analog Integrated Circuits. (3) F

Analysis and design of analog integrated circuits: analog circuit blocks, reference circuits, operational-amplifier circuits, feedback, and nonlinear circuits. Prerequisite: EEE 433 or equivalent.

EEE 525 VLSI Design. (3) F, S

Analysis and design of Very Large Scale Integrated (VLSI) Circuits. Physics of small devices, fabrication, regular structures, and system timing. Open only to graduate students.

EEE 526 VLSI Architectures. (3) F

Special-purpose architectures for signal processing. Design of array processor systems at the system level and processor level. High-level synthesis. Prerequisite: CSE 330 or EEE 407 or instructor approval.

EEE 527 Analog to Digital Converters. (3) F

A detailed introduction to the design of Nyquist rate, CMOS analog to digital converters. Prerequisite: EEE 523.

EEE 530 Advanced Silicon Processing. (3) S

Thin films, CVD, oxidation, diffusion, ion-implantation for VLSI, metallization, silicides, advanced lithography, dry etching, rapid thermal processing. Pre- or corequisite: EEE 435.

EEE 531 Semiconductor Device Theory I. (3) F

Transport and recombination theory, pn and Schottky barrier diodes, bipolar and junction field-effect transistors, and MOS capacitors and transistors. Prerequisite: EEE 436 or equivalent.

EEE 532 Semiconductor Device Theory II. (3) S

Advanced MOSFETs, charge-coupled devices, solar cells, photodetectors, light-emitting diodes, microwave devices, and modulation-doped structures. Prerequisite: EEE 531.

EEE 533 Semiconductor Process/Device Simulation. (3) F

Process simulation concepts, oxidation, ion implantation, diffusion, device simulation concepts, pn junctions, MOS devices, bipolar transistors. Prerequisite: EEE 436 or equivalent.

EEE 534 Semiconductor Transport. (3) S

Carrier transport in semiconductors. Hall effect, high electric field, Boltzmann equation, correlation functions, and carrier-carrier interactions. Prerequisites: EEE 434, 436 (or 531).

EEE 536 Semiconductor Characterization. (3) S

Measurement techniques for semiconductor materials and devices. Electrical, optical, physical, and chemical characterization methods. Prerequisite: EEE 436 or equivalent.

EEE 537 Semiconductor Optoelectronics I. (3) F

Electronic states in semiconductors, quantum theory of radiation, absorption processes, radiative processes, nonradiative processes, photoluminescence, and photonic devices. Prerequisites: EEE 434, 436 (or 531).

EEE 538 Semiconductor Optoelectronics II. (3) S

Material and device physics of semiconductor lasers, light-emitting diodes, and photodetectors. Emerging material and device technology in III-V semiconductors. Prerequisite: EEE 537.

EEE 539 Introduction to Solid-State Electronics. (3) F

Crystal lattices, reciprocal lattices, quantum statistics, lattice dynamics, equilibrium, and nonequilibrium processes in semiconductors. Prerequisite: EEE 434.

EEE 541 Electromagnetic Fields and Guided Waves. (3) N

Polarization and magnetization; dielectric, conducting, anisotropic, and semiconducting media; duality, uniqueness, and image theory; plane wave functions, waveguides, resonators, and surface guided waves. Prerequisite: EEE 440 or equivalent.

EEE 543 Antenna Analysis and Design. (3) F

Impedances, broadband antennas, frequency independent antennas, miniaturization, aperture antennas, horns, reflectors, lens antennas, and continuous sources design techniques. Prerequisite: EEE 443 or equivalent.

EEE 544 High Resolution Radar. (3) N

Fundamentals; wideband coherent design, waveforms, and processing; stepped frequency; synthetic aperture radar (SAR); inverse synthetic aperture radar (ISAR); imaging. Prerequisites: EEE 303 and 340 or equivalents.

EEE 545 Microwave Circuit Design. (3) S

Analysis and design of microwave attenuators, in-phase and quadrature-phase power dividers, magic tee's, directional couplers, phase shifters, DC blocks, and equalizers. Prerequisite: EEE 445 or instructor approval.

EEE 546 Advanced Fiber-Optics. (3) N

Theory of propagation in fibers, couplers and connectors, distribution networks, modulation, noise and detection, system design, and fiber sensors. Prerequisite: EEE 448 or instructor approval.

EEE 547 Microwave Solid-State Circuit Design I. (3) S

Application of semiconductor characteristics to practical design of microwave mixers, detectors, limiters, switches, attenuators, multipliers, phase shifters, and amplifiers. Prerequisite: EEE 545 or instructor approval.

EEE 548 Coherent Optics. (3) N

Diffraction, lenses, optical processing, holography, electro-optics, and lasers. Prerequisite: EEE 440 or equivalent.

EEE 549 Lasers. (3) N

Theory and design of gas, solid, and semiconductor lasers. Prerequisite: EEE 448 or instructor approval.

EEE 550 Transform Theory and Applications. (3) N

Introduction to abstract integration, function spaces, and complex analysis in the context of integral transform theory. Applications to signal analysis, communication theory, and system theory. Prerequisite: EEE 303.

EEE 551 Information and Coding Theory. (3) N

Fundamental theorems of information theory for sources and channels; convolutional and burst codes. Prerequisites: EEE 553, 554.

EEE 552 Digital Communications I. (3) S

Fundamentals of digital communications: complex signal theory; modulation; optimal coherent and incoherent receivers; coded modulation and the Viterbi algorithm. Prerequisites: EEE 455, 554.

EEE 553 Error-Correcting Codes. (3) S

Application of modern algebra to the design of random error-detecting and error-correcting block codes. Prerequisite: EEE 455.

EEE 554 Random Signal Theory I. (3) F

Application of statistical techniques to the representation and analysis of electrical signals and to communications systems analysis. Prerequisite: EEE 350 or instructor approval.

EEE 555 Random Signal Theory II. (3) N

Processing of signals in the presence of noise. Random signals, correlation, frequency spectra, estimation, filtering, noise, prediction, and transients. Prerequisite: EEE 554.

EEE 556 Detection and Estimation Theory. (3) S

Combination of the classical techniques of statistical inference and the random process characterization of communication, radar, and other modern data processing systems. Prerequisites: EEE 455, 554.

EEE 558 Digital Communications II. (3) F

Continuation of EEE 552. Advanced topics in digital communications: synchronization; multipath and fading; equalization; miscellaneous topics. Prerequisite: EEE 552.

EEE 571 Power System Transients. (3) N

Simple switching transients. Transient analysis by deduction. Damping of transients. Capacitor and reactor switching. Transient recovery voltage. Travelling waves on transmission lines. Lightning. Protection of equipment against transient overvoltages. Introduction to computer analysis of transients. Prerequisite: EEE 471.

EEE 572 Advanced Power Electronics. (3) N

Analysis of device operation, including thyristors, gate-turn-off thyristors, and transistors. Design of rectifier and inverter circuits. Applications such as variable speed drives, HVDC, motor control, and uninterruptible power supplies. Prerequisite: EEE 470.

EEE 573 Electric Power Quality. (3) S

Sinusoidal waveshape maintenance; study of momentary events, power system harmonics, instrumentation, filters, power conditioners, and other power quality enhancement methods. Prerequisite: EEE 360 or equivalent.

EEE 574 Computer Solution of Power Systems. (3) N

Algorithms for digital computation for power flow, fault, and stability analysis. Sparse matrix and vector programming methods, numerical integration techniques, stochastic methods, solution of the least squares problem. Prerequisite: EEE 471.

EEE 577 Power Engineering Operations and Planning. (3) F

Economic dispatch, unit commitment, dynamic programming, power system planning and operation, control, generation modeling, AGC, and power production. Prerequisite: EEE 471 or graduate standing.

EEE 579 Power Transmission and Distribution. (3) S

High-voltage transmission line electric design; conductors, corona, RI and TV noise, insulators, clearances. DC characteristic, feeders voltage drop, and capacitors. Prerequisite: EEE 470.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

EEE 581 Filtering of Stochastic Processes. (3) N

Modeling, estimation, and filtering of stochastic processes, with emphasis on the Kalman filter and its applications in signal processing and control. Prerequisites: EEE 482, 550, 554.

EEE 582 Linear System Theory. (3) S

Controllability, observability, and realization theory for multivariable continuous time systems. Stabilization and asymptotic state estimation. Disturbance decoupling, noninteracting control. Prerequisite: EEE 482.

EEE 585 Digital Control Systems. (3) F

Analysis and design of digital and sampled data control systems, including sampling theory, z-transforms, the state transition method, stability, design, and synthesis. Prerequisites: EEE 482, 550.

EEE 586 Nonlinear Control Systems. (3) N

Stability theory, including phase-plane, describing function, Liapunov's method, and frequency domain criteria for continuous and discrete, nonlinear, and time-varying systems. Prerequisite: EEE 482.

EEE 587 Optimal Control. (3) F

Optimal control of systems. Calculus of variations, dynamic programming, linear quadratic regulator, numerical methods, and Pontryagin's principle. Cross-listed as MAE 507. Credit is allowed for only EEE 587 or MAE 507. Prerequisite: EEE 482 or MAE 506.

EEE 588 Design of Multivariable Control Systems. (3) S

Practical tools for designing robust MIMO controllers. State feedback and estimation, model-based compensators, MIMO design methodologies, CAD, real-world applications. Prerequisite: EEE 480 or equivalent.

EEE 606 Adaptive Signal Processing. (3) F

Principles/applications of adaptive signal processing, adaptive linear combiner, Wiener least-squares solution, gradient search, performance surfaces, LMS/RLS algorithms, block time/frequency domain LMS. Prerequisites: EEE 506, 554.

EEE 607 Speech Coding for Multimedia Communications. (3) S

Speech and audio coding algorithms for applications in wireless communications and multimedia computing. Prerequisite: EEE 407. Pre- or corequisite: EEE 506.

EEE 631 Heterojunctions and Superlattices. (3) F

Principles of heterojunctions and quantum well structures, band line-ups, optical, and electrical properties. Introduction to heterojunction devices. Prerequisites: EEE 436, 531.

EEE 632 Heterojunction Devices. (3) N

Applications of heterostructures, quantum wells, and superlattice to modulation-doped FETs, heterostructure bipolar transistors, lasers, detectors, and modulators. Prerequisites: EEE 434 and 631 (or 537).

EEE 641 Advanced Electromagnetic Field Theory. (3) N

Cylindrical wave functions, waveguides, and resonators; spherical wave functions and resonators; scattering from planar, cylindrical, and spherical surfaces; Green's functions. Prerequisite: EEE 541 or equivalent.

EEE 643 Advanced Topics in Electromagnetic Radiation. (3) S

High-frequency asymptotic techniques, geometrical and physical theories of diffraction (GTD and PTD), moment method (MM), radar cross section (RCS) prediction, Fourier transforms in radiation, and synthesis methods. Prerequisite: EEE 543.

EEE 647 Microwave Solid-State Circuit Design II. (3) F

Practical design of microwave free-running and voltage-controlled oscillators using Gunn and Impatt diodes and transistors; analysis of noise characteristics of the oscillator. Prerequisites: EEE 545, 547.

EEE 686 Adaptive Control. (3) N

Main topics covered: adaptive identification, convergence, parametric models, performance and robustness properties of adaptive controllers, persistence of excitation, and stability. Prerequisites: EEE 582 and 586 or instructor approval.

EEE 731 Advanced MOS Devices. (3) S

Threshold voltage, subthreshold current, scaling, small geometry effects, hot electrons, and alternative structures. Prerequisite: EEE 531.

EEE 732 Advanced Bipolar Devices and Circuits. (3) N

Critical examination of new bipolar device and circuit technologies. Performance trade-offs, scaling effects, and modeling techniques. Prerequisite: EEE 531.

EEE 770 Advanced Topics in Power Systems. (3) N

Power system problems of current interest, approached at an advanced technical level, for mature students. Prerequisites: EEE 577 and 579 or equivalents; instructor approval.

Department of Industrial and Management Systems Engineering

Gary L. Hogg

Chair

(GWC 502) 480/965-3185

www.eas.asu.edu/~imse

PROFESSORS

BAILEY, DOOLEY, HENDERSON, HOGG, HUBELE, KEATS, MONTGOMERY, SMITH, UTTAL, WOLFE

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ANDERSON-ROWLAND, COCHRAN, MACKULAK, MOOR, ROBERTS, ROLLIER, RUNGER, SHUNK, VILLALOBOS, YE

ASSISTANT PROFESSORS

CARLYLE, FOWLER, MOU

The industrial engineer (IE) provides leadership for American organizations in reestablishing competitiveness in the global marketplace through system integration and productivity improvement. No challenge can be greater than improving productivity, which is the application of knowledge and skills to provide improved goods and services to enhance the quality of life, both on and off the job. This improvement must be achieved without waste of physical and human resources while maintaining the environmental balance. Industrial engineers are the "productivity people" who provide the necessary leadership and skills to integrate technology. This gives IEs a wide range of interests and responsibilities.

As in other engineering fields, industrial engineering is concerned with solving problems through the application of scientific and practical knowledge. What sets industrial engineering apart from other engineering disciplines is its broader scope. An IE relates to the total picture of productivity. An IE looks at the "big picture" of what makes society perform best—the right combination of human resources, natural resources, synthetic structures, and equipment. An IE bridges the gap between management and operations, dealing with and motivating people as well as determining what tools should be used and how they should be used.

An IE deals with people as well as things. In fact, industrial engineering is often called the "people-oriented profession." It is a primary function of the IE to integrate people and technology-oriented systems. Therefore, IEs are active in the fields of ergonomics and human factors.

To be competitive in this global economy, it is essential to emphasize and continually improve the quality of goods and services. Industrial engineering is the only engineering discipline offering course work in designing and implementing quality assurance systems.

The IE's skills are applicable to every kind of organization. IEs learn how to approach, think about, and solve productivity and integration problems regardless of their settings. IEs work in manufacturing facilities, banks, hospitals, government, transportation, construction, and social services. Within this wide variety of organizations, IEs get involved in projects such as designing and implementing

quality control systems, independent work groups, the work flow in a medical laboratory, real-time production control systems, computer-based management information systems, and manufacturing operating systems, to name a few. A unique feature of most industrial engineering assignments is that they involve interdisciplinary teams. For example, the IE might be the leader of a team consisting of electrical and mechanical engineers, accountants, computer scientists, and planners. This IE program gives the student the skills necessary to direct these teams. These skills include team building, brainstorming, group dynamics, and interpersonal relationships.

IEs have a sound background in technology integration, management theory and application, engineering economics and cost analysis. They are well equipped to deal with problems never seen before, making them prime candidates for promotion through the management career path, especially in high-tech organizations. In fact, more than half of all practicing IEs are in management positions. This area of expertise has placed the IE in the leadership role in the establishment of a new field of activity called "management of technology."

Industrial engineers are well trained in the development and use of analytical tools, and their most distinctive skill is in the area of model building. IEs must quickly learn and understand the problems of their clients. In this context, good people skills and good analytic skills are essential. This industrial engineering program offers both.

INDUSTRIAL ENGINEERING—B.S.E.

Degree Requirements

A minimum of 128 semester hours is necessary for the B.S.E. degree in Industrial Engineering; including 50 upper-division semester hours.

Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 81.

Course Requirements

See "Degree Requirements," page 199, for General Studies, school, and engineering core course requirements.

Industrial Engineering Major

The following courses are required:

ASE 485 Engineering Statistics <i>N2</i>	3
CSE 100 Principles of Programming <i>N3</i>	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
IEE 300 Economic Analysis for Engineers.....	3
IEE 305 Information Systems Engineering <i>N3</i>	3
IEE 360 Manufacturing Processes	3
IEE 361 Manufacturing Processes Lab	1
IEE 374 Quality Control <i>N2</i>	3
IEE 394 ST: Facilities Analysis and Design	4
or IEE 394 ST: Work Analysis and Design (4)	
IEE 431 Engineering Administration	3
IEE 461 Production Control.....	3
IEE 475 Simulating Stochastic Systems <i>N3</i>	3
IEE 476 Operations Research Techniques/Applications <i>N2</i>	4
IEE 490 Project in Design and Development.....	3

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

Technical elective.....	6
Total	48

**Industrial Engineering
Program of Study
Typical Four-Year Sequence**

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>S1/S2</i> ¹	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
or HU/SB elective (4)	
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
Total	15

Second Semester

ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ²	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ²	1
HU, SB, and awareness area course ³	3
or ECE 100 Introduction to Engineering Design <i>N3</i> (4)	
Total	17

Second Year

First Semester

CSE 100 Principles of Programming <i>N3</i>	3
IEE 300 Economic Analysis for Engineers.....	3
MAT 242 Elementary Linear Algebra.....	2
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ⁴	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ⁴	1
Total	16

Second Semester

ECE 210 Engineering Mechanics I: Statics.....	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
IEE 463 Computer Aided Manufacturing and Control	3
MAT 274 Elementary Differential Equations <i>N1</i>	3
Basic science elective ⁵	3
HU, SB, and awareness area course ³	3
Total	18

Third Year

First Semester

ASE 485 Engineering Statistics <i>N2</i>	3
IEE 305 Information Systems Engineering <i>N3</i>	3
IEE 374 Quality Control <i>N2</i>	3
IEE 394 ST: Facilities Analysis and Design	4
or IEE 394 ST: Work Analysis and Design (4)	
HU, SB, and awareness area course(s) ³	4
Total	17

Second Semester

ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 350 Structure and Properties of Materials	3
IEE 360 Manufacturing Processes	3
IEE 361 Manufacturing Processes Lab	1

IEE 476 Operations Research Techniques/Applications N2	4
Total	17

Fourth Year

First Semester

ECE 301 Electrical Networks I	4
IEE 431 Engineering Administration	3
IEE 461 Production Control.....	3
IEE 475 Simulating Stochastic Systems N3	3
HU, SB, and awareness area course ³	3
Total	16

Second Semester

ECE 400 Engineering Communications L2	3
IEE 490 Project in Design and Development.....	3
Technical elective.....	6
Total	12

- ¹ Students who have taken no high school chemistry should take CHM 113 and 116.
- ² Both PHY 121 and 122 must be taken to secure S1 or S2 credit.
- ³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.
- ⁴ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.
- ⁵ Must be an earth science or life science course; if physics or chemistry, the course must be of a more advanced level than CHM 114 or 116 or PHY 131.

INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING (IEE)

IEE 300 Economic Analysis for Engineers. (3) F, S

Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Prerequisites: ECE 100; MAT 270.

IEE 305 Information Systems Engineering. (3) F

Emphasis on systems analysis, design and implementation of information systems using fourth generation languages and alternative data base structures. Prerequisite: CSE 100. *General Studies: N3.*

IEE 360 Manufacturing Processes. (3) F, S

Production technique and equipment. Casting and molding, forming, machining, joining and assembly, computer-integrated manufacturing, rapid prototyping, and electronics manufacturing. Cross-listed as MAE 351. Credit is allowed for only IEE 360 or MAE 351. Prerequisite: ECE 350.

IEE 361 Manufacturing Processes Lab. (1) F, S

Series of labs designed to illustrate concepts presented in IEE 360 on production technique and equipment. Corequisite: IEE 360 (or MAE 351).

IEE 367 Methods Engineering and Facilities Design. (4) F

Analyzing and designing work systems for productivity, including time and motion studies, human factors, material handling, facility layout and location. Lecture, lab. Prerequisites: CSE 100, IEE 300.

IEE 374 Quality Control. (3) F

Control charting and other statistical process control techniques. Organization and managerial aspects of quality assurance, plus acceptance sampling plans. Prerequisite: ECE 380. *General Studies: N2.*

IEE 394 ST: Special Topics. (4) F, S

- (a) Facilities Analysis and Design
- (b) Work Analysis and Design

IEE 431 Engineering Administration. (3) F

Introducing quantitative and qualitative approaches to management functions, engineering administration, organizational analysis, decision making, and communication. Prerequisite: senior standing.

IEE 437 Human Factors Engineering. (3) F

Study of the human psychological and physiological factors that underlie the design of equipment and the interaction between people and machines.

IEE 461 Production Control. (3) F

Techniques for the planning, control, and evaluation of production systems. Project management, forecasting, inventory control, scheduling, enterprise requirements planning. Prerequisites: ASE 485; CSE 100; IEE 476.

IEE 463 Computer-Aided Manufacturing and Control. (3) S

Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning and robotics. Prerequisite: C programming capability. *General Studies: N3.*

IEE 475 Simulating Stochastic Systems. (3) F, S

Analysis of stochastic systems using basic queuing networks and discrete event simulation. Basic network modeling, shared resources, routing, assembly logic. Not open to students with credit in IEE 545. Prerequisites: ASE 485; CSE 100; IEE 476. *General Studies: N3.*

IEE 476 Operations Research Techniques/Applications. (4) F, S

Industrial systems applications with operations research techniques. Resource allocation, product mix, production, shipping, task assignment, market share, machine repair, customer service. Not open to students with credit in IEE 546. Prerequisites: ASE 485; CSE 100. *General Studies: N2.*

IEE 490 Project in Design and Development. (3) F, S

Individual or team capstone project in creative design and synthesis. Prerequisite: senior standing.

IEE 505 Applications Engineering. (3) F

Develop working knowledge of application systems development tools needed for computer integrated enterprise. Includes techniques for application generation in fourth and fifth generation software environments. Topics include client server network systems, decision support systems, and transaction systems in distributed environment.

IEE 511 Analysis of Decision Processes. (3) S

Methods of making decisions in complex environments and statistical decision theory; effects of risk, uncertainty, and strategy on engineering and managerial decisions. Prerequisite: ECE 380.

IEE 520 Ergonomics Design. (3) S

Human physiological and psychological factors in the design of work environments and in the employment of people in man-machine systems. Open-shop lab assignments in addition to class work. Prerequisite: IEE 437 or 547.

IEE 530 Enterprise Modeling. (3) S

Focus on social, economic, and technical models of the enterprise with emphasis on the management of technological resources. Included are organization, econometric, financial, and large-scale mathematical models.

IEE 531 Topics in Engineering Administration. (3) S 2000

Consideration given to philosophical, psychological, political, and social implications of administrative decisions. Prerequisite: IEE 532 or instructor approval.

IEE 532 Management of Technology. (3) F

Topics include designing a technical strategy; technological forecasting; interfacing marketing engineering and manufacturing; designing and managing innovation systems; creativity; application of basic management principles to technology management. Prerequisite: IEE 431 or 541 or instructor approval.

IEE 533 Scheduling and Network Analysis Models. (3) S

Application of scheduling and sequencing algorithms, deterministic and stochastic network analysis, and flow algorithms. Prerequisites: ECE 380; IEE 476 (or 546).

IEE 541 Engineering Administration. (3) F

Introducing quantitative and qualitative approaches to management functions, engineering administration, organizational analysis, decision making, and communication. IEE 431 students ineligible.

IEE 543 Computer-Aided Manufacturing and Control. (3) S

Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning and robotics. IEE 463 students ineligible. Prerequisite: C programming capability.

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

IEE 545 Simulating Stochastic Systems. (3) F, S

Analysis of stochastic systems using basic queuing networks and discrete event simulation. Basic network modeling, shared resources, routing, assembly logic. Not open to students with credit in IEE 475. Prerequisites: ASE 485; CSE 100 (or equivalent); IEE 476 (or 546).

IEE 546 Operations Research Techniques/Applications. (4) F, S
Students model and analyze industrial systems applications with operations research techniques. Resource allocation, product mix, production, shipping, task assignment, market share, machine repair, customer service. Not open to students with credit in IEE 476. Prerequisites: ASE 485; CSE 100.

IEE 547 Human Factors Engineering. (3) F

Study of people at work; designing for human performance effectiveness and productivity. Considerations of human physiological and psychological factors. Open only to students without previous credit for IEE 437.

IEE 552 Strategic Technological Planning. (3) S

Study of concept of strategy, strategy formulation process, and strategic planning methodologies with emphasis on engineering design and manufacturing strategy, complemented with case studies. An analytical executive planning decision support system is presented and used throughout course. Pre- or corequisite: IEE 545 or 566 or 567 or 574 or 575.

IEE 560 Database Concepts for Industrial Management Systems. (3) S

Application of object oriented database technology concepts to manufacturing and enterprise systems.

IEE 561 Production Systems. (3) F, S

Understanding how factories operate, how performance is measured, and how operational changes impact performance metrics. Operational philosophies, increasing production efficiency through quantitative methods. Prerequisites: ASE 485 (or equivalent); IEE 475, 476.

IEE 562 Computer-Aided Manufacturing (CAM) Tools. (3) F

Current topics in automation, distributed control, control code generation, control logic validation, CAM integration, CAD/CAM data structures, planning for control systems. Topics vary by semester. Prerequisite: IEE 463 or 543 or equivalent.

IEE 563 Systems Analysis for Distributed Systems. (3) S

Analysis and design of distributed groupware applications for manufacturing and enterprise systems. Prerequisite: ECE 380.

IEE 564 Planning for Computer-Integrated Manufacturing. (3) F

Theory and use of IDEF methodology in planning for flexible manufacturing, robotics, and real-time control. Simulation concepts applied to computer-integrated manufacturing planning. Prerequisite: IEE 463 or 543.

IEE 565 Computer-Integrated Manufacturing Research. (3) S

Determination and evaluation of research areas in computer-integrated manufacturing, including real-time software, manufacturing information systems, flexible and integrated manufacturing systems, robotics, and computer graphics. Prerequisite: IEE 564.

IEE 566 Simulation in Manufacturing. (3) F

Use of simulation in computer-integrated manufacturing with an emphasis on modeling material handling systems. Programming, declarative, and intelligence-based simulation environments. Prerequisite: IEE 545.

IEE 567 Simulation System Analysis. (3) S

Simulation modeling of processes involving discrete and continuous system components. Topics include random number generators, output analysis, variance reduction, and statistical issues related to simulation. Prerequisite: IEE 545.

IEE 569 Advanced Statistical Methods. (3) F 2000

Application of statistical inference procedures, based on ranks, to engineering problems. Efficient alternatives to classical statistical inference constrained by normality assumptions. Prerequisite: ASE 485 or 500.

IEE 570 Advanced Quality Control. (3) S

Economic-based acceptance sampling, multiattribute acceptance sampling, narrow limit gauging in inspector error and attributes acceptance sampling, principles of quality management, and selected topics from current literature. Prerequisite: ASE 485 or 500 or equivalent.

IEE 571 Quality Management. (3) F

Total quality concepts, quality strategies, quality and competitive position, quality costs, vendor relations, the quality manual, and quality in the services. Prerequisite: IEE 431 or 541.

IEE 572 Design of Engineering Experiments. (3) F, S

Analysis of variance and experimental design. Topics include general design methodology, incomplete blocks, confounding, fractional replication, and response surface methodology. Prerequisite: ASE 485 or 500.

IEE 573 Reliability Engineering. (3) S

Nature of reliability, time to failure densities, series/parallel/standby systems, complex system reliability, Bayesian reliability, and sequential reliability tests. Prerequisite: ECE 380.

IEE 574 Applied Deterministic Operations Research Models. (3) F, S

Advanced techniques in operations research are developed for the solution of complex industrial systems problems. Goal programming, integer programming, heuristic methods, dynamic and nonlinear programming. Prerequisites: IEE 476 (or 546); MAT 242.

IEE 575 Applied Stochastic Operations Research Models. (3) S

Students formulate and solve industrial systems problems with stochastic components using analytical techniques. Convolution, continuous-time Markov chains, queues with batching, priorities, balking, open/closed queuing networks. Prerequisites: ASE 485; IEE 476 (or 546).

IEE 577 Decision and Expert Systems Methodologies. (3) F

Application of artificial intelligence methodologies in decision support systems. Topics include neural networks, fuzzy logic systems, and expert systems. Prerequisite: CSE 100 or equivalent.

IEE 578 Regression Analysis. (3) F

A course in regression model building oriented toward engineers/physical scientists. Topics include linear regression, diagnostics biased and robust fitting, nonlinear regression. Prerequisite: ASE 485 or 500.

IEE 579 Time Series Analysis and Forecasting. (3) F 1999

Forecasting time series by the Box-Jenkins and exponential smoothing techniques; existing digital computer programs are utilized to augment the theory. Prerequisites: ASE 485 (or 500); IEE 461.

IEE 582 Response Surfaces and Process Optimization. (3) S

An introduction to response surface method and its applications. Topics include steepest ascent, canonical analysis, designs, and optimality criteria. Prerequisite: IEE 572.

IEE 672 Advanced Topics in Experimental Design. (3) S 2000

Engineering applications of factorial and fractional factorial designs with randomization restrictions, analysis techniques in parameter comparison, missing data, unbalanced designs. Prerequisite: IEE 572 or instructor approval.

IEE 677 Regression and Linear Models. (3) S 2001

General linear models, applications, theory, including least squares, maximum likelihood estimation, properties of estimators, likelihood ratio tests and computational procedures. Prerequisite: IEE 578 or instructor approval.

IEE 679 Time Series Analysis and Control. (3) F 2000

Identification, estimation, diagnostic checking techniques for ARIMA models, transfer functions, multiple time series models for feedback and feedforward control schemes. Prerequisite: IEE 579 or instructor approval.

IEE 681 Reliability, Availability, and Serviceability. (3) F 2000

Organizing hardware and software, integrity and fault-tolerant design, maintenance design and strategy, Markov models, fault-free analysis, and military standards. Prerequisite: ECE 380.

Department of Mechanical and Aerospace Engineering

Don L. Boyer
Chair
(ECG 346) 480/965-3291
www.eas.asu.edu/~mae

PROFESSORS

BOYER, CHATTOPADHYAY, DAVIDSON, EVANS,
FERNANDO, HIRLEMAN, JANKOWSKI, KRAJCINOVIC,
LAANANEN, LIU, PECK, REED, ROY, SARIC, SHAH,
SIERADZKI, TSENG, WIE, YAO

ASSOCIATE PROFESSORS

CHEN, KOURIS, KUO, MIGNOLET, RANKIN,
SQUIRES, WELLS

ASSISTANT PROFESSORS

CHAPSKY, LEE, MCNEILL, PERALTA, PHELAN

The Department of Mechanical and Aerospace Engineering is the administrative home for two undergraduate majors: Aerospace Engineering and Mechanical Engineering.

Both majors build on the broad exposure to the engineering, chemical, and physical sciences and the mathematics embodied in the General Studies and engineering core courses required of all engineering students.

The Aerospace Engineering major provides students an education in technological areas critical to the design and development of aerospace vehicles and systems. Aerospace Engineering graduates are typically employed at government laboratories (e.g., NASA) and in a wide range of aerospace and mechanical industries. The Mechanical Engineering major is perhaps one of the most broadly applicable programs in engineering, providing education for a wide variety of employment opportunities.

The two majors, discussed in more detail below, can serve as entry points to immediate professional employment or to graduate study. The emphasis in all fields is on the development of fundamental knowledge that will have long-lasting utility in our rapidly changing technical society.

DEGREE REQUIREMENTS

All degree programs in the department require that students attain a minimum GPA of 2.00 in the engineering core and in the major and take a minimum of 50 upper-division semester hours in order to be eligible for graduation. Also, the department may require additional or remedial course work for those students who have demonstrated a trend toward academic difficulties.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 81.

COURSE REQUIREMENTS

General Studies

See "Course Requirements," page 208, for General Studies, school, and engineering core course requirements.

Engineering Core Options

Among the options listed on page 208 as part of the engineering core requirements, students in the Department of Mechanical and Aerospace Engineering are required to take the following:

ECE 100 Introduction to Engineering Design N3	4
ECE 210 Engineering Mechanics I: Statics.....	3
ECE 300 Intermediate Engineering Design LI.....	3
ECE 301 Electrical Networks I	4
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 340 Thermodynamics.....	3
ECE 350 Structure and Properties of Materials	3
Total	26

AEROSPACE ENGINEERING—B.S.E.

The goal of the Aerospace Engineering program is to provide students with an education in technological areas critical to the design and development of aerospace vehicles and systems. The program emphasizes aeronautical engineering with topics in required courses covering aerodynamics, aerospace materials, aerospace structures, propulsion, flight mechanics, aircraft performance, and stability and control. Astronautic topics such as orbital mechanics, attitude dynamics, spacecraft control, and rocket propulsion are also covered in required courses.

Design is integrated throughout the curriculum beginning with ECE 100 Introduction to Engineering Design and followed later by ECE 300 Intermediate Engineering Design, both of which focus on basic design theory as well as professional practice. These required courses are followed by topic-specific design content in aerospace engineering courses in the junior and senior years. The senior capstone design course integrates design and analysis topics from the earlier courses and completes the required design sequence. This sequence includes a minimum of 20 semester hours of required design. In addition, many of the aerospace technical electives have design content.

Laboratory experience is provided in the areas of aerodynamics, aerospace structures, and vibrations. Laboratory facilities include four major wind tunnels, an integrated mechanical-testing laboratory, a controls laboratory, and a vibrations laboratory.

Aerospace Engineering Major

Aerospace Engineering students are required to take the following two courses in addition to those required for the major:

MAT 242 Elementary Linear Algebra	2
PHY 361 Introductory Modern Physics.....	3

The Aerospace Engineering major consists of the following courses:

ECE 384 Numerical Analysis for Engineers I.....	2
ECE 386 Partial Differential Equations for Engineers.....	2
EEE 350 Random Signal Analysis	3
MAE 317 Dynamic Systems and Control.....	3
MAE 361 Aerodynamics I.....	3

MAE 413 Aircraft Performance, Stability, and Control	3
MAE 415 Vibration Analysis	4
MAE 425 Aerospace Structures	4
MAE 444 Fundamentals of Aerospace Design	3
MAE 460 Gas Dynamics	3
MAE 462 Space Vehicle Dynamics and Control	3
MAE 463 Propulsion	3
MAE 464 Aerospace Laboratory	3
MAE 468 Aerospace Systems Design L2	3
Area of emphasis (technical electives)	6
Total	48

Aerospace Engineering Areas of Emphasis

To further the design experience, all Aerospace Engineering students must choose at least one technical elective from the following list of courses:

MAE 426 Design of Aerospace Structures	3
MAE 461 Aerodynamics II	3
MAE 465 Rocket Propulsion	3
MAE 466 Rotary Wing Aerodynamics and Performance	3
MAE 467 Aircraft Performance	3
MAE 469 Projects in Astronautics and Aeronautics	3

The remaining technical elective(s) may be selected from among any of the courses listed in the following course tables or from courses listed under the Mechanical Engineering areas of emphasis. The courses are grouped so that the student may select an elective package of closely related courses. A student may, with prior approval of the advisor and department, select a general area and a corresponding set of courses not listed that would support a career objective not covered by the following categories:

Aerodynamics. Select from these courses:

MAE 372 Fluid Mechanics	3
MAE 435 Turbomachinery	3
MAE 461 Aerodynamics II	3
MAE 463 Propulsion	3
MAE 466 Rotary Wing Aerodynamics and Performance	3
MAE 471 Computational Fluid Dynamics	3
MAE 490 Projects in Design and Development L2	3
MAT 421 Applied Computational Methods N3	3

Aerospace Materials. Select from these courses:

MAE 455 Polymers and Composites	3
MSE 355 Introduction to Materials Science and Engineering	3
MSE 420 Physical Metallurgy	3
MSE 440 Mechanical Properties of Solids	3
MSE 441 Analysis of Material Failures	3
MSE 450 X-ray and Electron Diffraction	3
MSE 471 Introduction to Ceramics	3

Aerospace Structures. Select from these courses:

MAE 404 Finite Elements in Engineering	3
MAE 426 Design of Aerospace Structures	3
MAE 455 Polymers and Composites	3
MAE 490 Projects in Design and Development L2	3

Computer Methods. Select from these courses:

ASE 485 Engineering Statistics N2	3
CSE 310 Data Structures and Algorithms II	3
CSE 422 Microprocessor System Design II	4
CSE 428 Computer-Aided Processes	3

IEE 463 Computer-Aided Manufacturing and Control N3	3
IEE 475 Simulating Stochastic Systems N3	3
MAE 404 Finite Elements in Engineering	3
MAE 406 CAD/CAM Applications in MAE	4
MAE 471 Computational Fluid Dynamics	3
MAE 541 CAD Tools for Engineers	3
MAT 421 Applied Computational Methods N3	3
MAT 423 Numerical Analysis I N3	3
MAT 425 Numerical Analysis II N3	3

Design. Select from these courses:

MAE 341 Mechanism Analysis and Design	3
MAE 404 Finite Elements in Engineering	3
MAE 406 CAD/CAM Applications in MAE	4
MAE 426 Design of Aerospace Structures	3
MAE 435 Turbomachinery	3
MAE 442 Mechanical Systems Design	3
MAE 446 Thermal Systems Design	3
MAE 455 Polymers and Composites	3
MAE 466 Rotary Wing Aerodynamics and Performance	3
MAE 467 Aircraft Performance	3
MAE 490 Projects in Design and Development L2	3
MSE 440 Mechanical Properties of Solids	3
MSE 441 Analysis of Material Failures	3

Mechanical. Any courses listed under "Mechanical Engineering Areas of Emphasis" may be selected.

Propulsion. Select from these courses:

MAE 382 Thermodynamics	3
MAE 388 Heat Transfer	3
MAE 434 Internal Combustion Engines	3
MAE 435 Turbomachinery	3
MAE 436 Combustion	3
MAE 461 Aerodynamics II	3
MAE 465 Rocket Propulsion	3
MAE 466 Rotary Wing Aerodynamics and Performance	3
MAE 471 Computational Fluid Dynamics	3
MAE 490 Projects in Design and Development L2	3

System Dynamics and Control. Select from these courses:

CSE 428 Computer-Aided Processes	3
EEE 480 Feedback Systems	4
EEE 482 Introduction to State Space Methods	3
MAE 417 Control System Design	3
MAE 447 Robotics and Its Influence on Design	3
MAE 469 Projects in Astronautics or Aeronautics	3
MAE 490 Projects in Design and Development L2	3

TYPICAL FOUR-YEAR SEQUENCE

The first two years are usually devoted to the General Studies and engineering core requirements. Thus, the degree programs in the department share essentially the same course schedule for that period of time. A typical schedule is given below:

Aerospace Engineering Program of Study Typical Four-Year Sequence First Year

First Semester

CHM 114 General Chemistry for Engineers S1/S2	4
or CHM 116 General Chemistry S1/S2 (4)	

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

ECE 100 Introduction to Engineering Design <i>N3</i>4 or HU/SB elective	4
ENG 101 First-Year Composition.....3	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>4	4
Total	15

Second Semester

ENG 102 First-Year Composition.....3	3
MAT 242 Elementary Linear Algebra.....2	2
MAT 271 Calculus with Analytic Geometry II <i>NI</i>4	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹3	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹1	1
HU, SB, and awareness area course ²3 or ECE 100 Introduction to Engineering Design <i>N3</i> (4)	3
Total	16

Second Year**First Semester**

ECE 210 Engineering Mechanics I: Statics.....3	3
ECE 350 Structure and Properties of Materials3	3
MAT 272 Calculus with Analytic Geometry III <i>NI</i>4	4
MAT 274 Elementary Differential Equations <i>NI</i>3	3
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ³3	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ³1	1
Total	17

Second Semester

ECE 301 Electrical Networks I.....4	4
ECE 312 Engineering Mechanics II: Dynamics.....3	3
ECE 313 Introduction to Deformable Solids.....3	3
ECE 340 Thermodynamics.....3	3
ECE 384 Numerical Analysis for Engineers I.....2	2
ECE 386 Partial Differential Equations for Engineers.....2	2
Total	17

Third Year**First Semester**

ECE 300 Intermediate Engineering Design <i>L1</i>3	3
MAE 317 Dynamic Systems and Control.....3	3
MAE 361 Aerodynamics I.....3	3
MAE 425 Aerospace Structures4	4
HU, SB, and awareness area course ²3	3
Total	16

Second Semester

EEE 350 Random Signal Analysis.....3	3
MAE 413 Aircraft Performance, Stability, and Control.....3	3
MAE 444 Fundamentals of Aerospace Design.....3	3
MAE 460 Gas Dynamics3	3
HU, SB, and awareness area course ²3	3
Total	15

Fourth Year**First Semester**

MAE 415 Vibration Analysis.....4	4
MAE 462 Space Vehicle Dynamics and Control.....3	3
MAE 463 Propulsion3	3
PHY 361 Introductory Modern Physics.....3	3
Required design technical elective.....3	3
Total	16

Second Semester

MAE 464 Aerospace Laboratory.....3	3
MAE 468 Aerospace Systems Design <i>L2</i>3	3
Technical electives	3

HU, SB, and awareness area courses ²7	7
Total	16

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.

³ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

MECHANICAL ENGINEERING—B.S.E.

Mechanical engineering is a creative discipline that draws upon a number of basic sciences to design the devices, machines, processes, and systems that involve mechanical work and its conversion from and into other forms. It includes: the conversion of thermal, chemical, and nuclear energy into mechanical energy through various engines and power plants; the transport of energy via devices like heat exchangers, pipelines, gears, and linkages; the use of energy to perform a variety of tasks for the benefit of society, such as in transportation vehicles of all types, manufacturing tools and equipment, and household appliances. Furthermore, since all manufactured products must be constructed of solid materials and because most products contain parts that transmit forces, mechanical engineering is involved in the structural integrity and materials selection for almost every product on the market.

Mechanical engineers are employed in virtually every kind of industry. They are involved with seeking new knowledge through research, with doing creative design and development, and with the construction, control, management, and sales of the devices and systems needed by society. Therefore, a major strength of a mechanical engineering education is the flexibility it provides in future employment opportunities for its graduates.

The undergraduate curriculum includes the study of: the principles governing the use of energy; the principles of design, instruments and control devices; and the application of these studies to the creative solution of practical, modern problems.

Design is integrated throughout the curriculum, beginning with ECE 100 Introduction to Engineering Design and followed later by ECE 300 Intermediate Engineering Design, both of which focus on basic design theory as well as professional practice. These required courses are followed by topic specific design content in mechanical engineering courses in the junior and senior years. The senior capstone design course combines the design topics from the earlier courses and completes the required design sequence. In addition, many of the mechanical technical electives have design content.

Laboratory experience is provided in the areas of thermofluid systems, mechanics of materials, and controls. Laboratory facilities include a thermal systems laboratory, an integrated mechanical-testing laboratory, a controls laboratory, and a manufacturing laboratory.

Mechanical Engineering Major

Mechanical Engineering students are required to select the following supplemental courses:

ECE 384 Numerical Analysis for Engineers I.....2	2
ECE 386 Partial Differential Equations for Engineers.....2	2
EEE 350 Random Signal Analysis.....3	3
MAT 242 Elementary Linear Algebra.....2	2
PHY 361 Introductory Modern Physics.....3	3

The Mechanical Engineering major requires the following departmental courses:

MAE 317 Dynamic Systems and Control.....	3
MAE 318 Dynamic Systems and Control Laboratory.....	1
MAE 371 Fluid Mechanics.....	3
MAE 388 Heat Transfer.....	3
MAE 422 Mechanics of Materials.....	4
MAE 441 Principles of Design.....	3
MAE 443 Engineering Design.....	3
MAE 490 Projects in Design and Development L2.....	3
MAE 491 Experimental Mechanical Engineering.....	3
Area of emphasis (technical electives).....	15
Total.....	41

Mechanical Engineering Areas of Emphasis

Technical electives may be selected from among any of the following courses or from courses listed under the Aerospace Engineering areas of emphasis. The courses are grouped to assist a student in assembling an elective package of closely related courses. Students preferring a broader technical background may choose courses from different areas. With prior approval of the advisor and department, a student may select a general area and a corresponding set of courses not listed that would support a career objective not covered by the following categories:

Aerospace. Any courses listed under Aerospace Engineering areas of emphasis may be selected.

Biomechanical. Select from these courses:

BME 411 Biomedical Engineering I.....	3
BME 412 Biomedical Engineering II.....	3
BME 416 Biomechanics.....	3
BME 419 Biocontrol Systems.....	3
EEE 302 Electrical Networks II.....	3
EEE 434 Quantum Mechanics for Engineers.....	3

Computer Methods. Select from these courses:

ASE 485 Engineering Statistics N2.....	3
CSE 310 Data Structures and Algorithms II.....	3
CSE 422 Microprocessor System Design II.....	4
CSE 428 Computer-Aided Processes.....	3
IEE 463 Computer-Aided Manufacturing and Control N3.....	3
IEE 475 Simulating Stochastic Systems N3.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 406 CAD/CAM Applications in MAE.....	4
MAE 471 Computational Fluid Dynamics.....	3
MAE 541 CAD Tools for Engineers.....	3
MAT 421 Applied Computational Methods N3.....	3
MAT 423 Numerical Analysis I N3.....	3
MAT 425 Numerical Analysis II N3.....	3

Control and Dynamic Systems. Select from these courses:

CSE 428 Computer-Aided Processes.....	3
EEE 360 Energy Conversion and Transport.....	4
IEE 463 Computer-Aided Manufacturing and Control N3.....	3
MAE 413 Aircraft Performance, Stability, and Control.....	3
MAE 417 Control System Design.....	3
MAE 462 Space Vehicle Dynamics and Control.....	3
MAE 467 Aircraft Performance.....	3

Design. Select from these courses:

MAE 341 Mechanism Analysis and Design.....	3
MAE 351 Manufacturing Processes.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 406 CAD/CAM Applications in MAE.....	4
MAE 413 Aircraft Performance, Stability, and Control.....	3
MAE 417 Control System Design.....	3
MAE 434 Internal Combustion Engines.....	3
MAE 435 Turbomachinery.....	3
MAE 442 Mechanical Systems Design.....	3
MAE 446 Thermal Systems Design.....	3
MAE 447 Robotics and Its Influence on Design.....	3
MAE 462 Space Vehicle Dynamics and Control.....	3
MAE 467 Aircraft Performance.....	3

Energy Systems. Select from these courses:

EEE 360 Energy Conversion and Transport.....	4
MAE 372 Fluid Mechanics.....	3
MAE 382 Thermodynamics.....	3
MAE 434 Internal Combustion Engines.....	3
MAE 435 Turbomachinery.....	3
MAE 436 Combustion.....	3
MAE 446 Thermal Systems Design.....	3

Engineering Mechanics. Select from these courses:

MAE 341 Mechanism Analysis and Design.....	3
MAE 402 Introduction to Continuum Mechanics.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 413 Aircraft Performance, Stability, and Control.....	3
MAE 415 Vibration Analysis.....	4
MAE 426 Design of Aerospace Structures.....	3
MAE 442 Mechanical Systems Design.....	3
MAE 460 Gas Dynamics.....	3
MAE 461 Aerodynamics II.....	3
MAE 471 Computational Fluid Dynamics.....	3
MAT 421 Applied Computational Methods N3.....	3
MAT 423 Numerical Analysis I N3.....	3
MSE 440 Mechanical Properties of Solids.....	3

Manufacturing. Select from these courses:

CSE 428 Computer-Aided Processes.....	3
IEE 300 Economic Analysis for Engineers.....	3
IEE 374 Quality Control N2.....	3
IEE 461 Production Control.....	3
IEE 463 Computer-Aided Manufacturing and Control N3.....	3
MAE 341 Mechanism Analysis and Design.....	3
MAE 351 Manufacturing Processes.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 442 Mechanical Systems Design.....	3
MAE 447 Robotics and Its Influence on Design.....	3
MAE 455 Polymers and Composites.....	3
MSE 355 Introduction to Materials Science and Engineering.....	3
MSE 420 Physical Metallurgy.....	3
MSE 431 Corrosion and Corrosion Control.....	3
MSE 440 Mechanical Properties of Solids.....	3

Stress Analysis, Failure Prevention, and Materials.

Select from these courses:

MAE 341 Mechanism Analysis and Design.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 426 Design of Aerospace Structures.....	3
MAE 447 Robotics and Its Influence on Design.....	3
MAE 455 Polymers and Composites.....	3
MSE 355 Introduction to Materials Science and Engineering.....	3

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

MSE 420 Physical Metallurgy	3
MSE 431 Corrosion and Corrosion Control.....	3
MSE 440 Mechanical Properties of Solids	3
MSE 450 X-ray and Electron Diffraction	3

Thermosciences. Select from these courses:

MAE 372 Fluid Mechanics	3
MAE 382 Thermodynamics.....	3
MAE 433 Air Conditioning and Refrigeration	3
MAE 434 Internal Combustion Engines.....	3
MAE 435 Turbomachinery	3
MAE 436 Combustion	3
MAE 446 Thermal Systems Design	3
MAE 460 Gas Dynamics	3
MAE 463 Propulsion	3
MAE 471 Computational Fluid Dynamics	3

**Mechanical Engineering
Program of Study
Typical Four-Year Sequence**

First Year**First Semester**

CHM 114 General Chemistry for Engineers <i>SI/S2</i>	4
or CHM 116 General Chemistry <i>SI/S2</i> (4)	
ECE 100 Introduction to Engineering Design <i>N3</i>	4
or HU, SB elective	
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>NI</i>	4
Total	15

Second Semester

ENG 102 First-Year Composition.....	3
MAT 242 Elementary Linear Algebra.....	2
MAT 271 Calculus with Analytic Geometry II <i>NI</i>	4
PHY 121 University Physics I: Mechanics <i>SI/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>SI/S2</i> ¹	1
HU, SB, and awareness area course ²	3
or ECE 100 Introduction to Engineering Design <i>N3</i> (4)	
Total	16

Second Year**First Semester**

ECE 210 Engineering Mechanics I: Statics.....	3
ECE 350 Structure and Properties of Materials	3
MAT 272 Calculus with Analytic Geometry III <i>NI</i>	4
MAT 274 Elementary Differential Equations <i>NI</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>SI/S2</i> ³	3
PHY 132 University Physics Laboratory II <i>SI/S2</i> ³	1
Total	17

Second Semester

ECE 301 Electrical Networks I	4
ECE 312 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 340 Thermodynamics.....	3
ECE 386 Partial Differential Equations for Engineers.....	2
Total	15

Third Year**First Semester**

ECE 300 Intermediate Engineering Design <i>L1</i>	3
MAE 317 Dynamic Systems and Control.....	3
MAE 318 Dynamic Systems and Control Laboratory.....	1
MAE 371 Fluid Mechanics.....	3
MAE 422 Mechanics of Materials.....	4

HU, SB, and awareness area course ²	3
Total	17

Second Semester

ECE 384 Numerical Analysis for Engineers I.....	2
EEE 350 Random Signal Analysis	3
MAE 388 Heat Transfer.....	3
MAE 441 Principles of Design.....	3
HU, SB, and awareness area course ²	3
Technical elective	3
Total	17

Fourth Year**First Semester**

MAE 491 Experimental Mechanical Engineering.....	3
PHY 361 Introductory Modern Physics.....	3
HU, SB, and awareness area course(s) ²	4
Technical electives	6
Total	16

Second Semester

MAE 443 Engineering Design.....	3
MAE 490 Projects in Design and Development <i>L2</i>	3
HU, SB, and awareness area course ²	3
Technical electives	6
Total	15

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.² Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.³ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.**MECHANICAL AND AEROSPACE ENGINEERING (MAE)****MAE 317 Dynamic Systems and Control.** (3) F, S

Modeling and representations of dynamic physical systems, including transfer functions, block diagrams, and state equations. Transient response. Principles of feedback control and linear system analysis, including root locus and frequency response. Prerequisite: ECE 312. Corequisite for Mechanical Engineering majors only: MAE 318. Pre- or corequisite: ECE 386.

MAE 318 Dynamic Systems and Control Lab. (1) F, S

Series of labs designed to illustrate concepts presented in MAE 317. Lab. Corequisite for Mechanical Engineering majors only: MAE 317.

MAE 341 Mechanism Analysis and Design. (3) A

Positions, velocities, and accelerations of machine parts; cams, gears, flexible connectors, and rolling contact; introduction to synthesis. Prerequisite: ECE 312.

MAE 351 Manufacturing Processes. (3) F, S

Production technique and equipment. Casting and molding, forming, machining, joining and assembly, computer-integrated manufacturing, rapid prototyping, and electronics manufacturing. Cross-listed as IEE 360. Credit is allowed for only IEE 360 or MAE 351. Prerequisite: ECE 350.

MAE 361 Aerodynamics I. (3) A

Fluid statics, conservation principles, stream function, velocity potential, vorticity, inviscid flow, Kutta-Joukowski, thin-airfoil theory, and panel methods. Prerequisites: ECE 312, 340.

MAE 371 Fluid Mechanics. (3) F, S

Introductory concepts of fluid motions; fluid statics; control volume forms of basic principles; viscous internal flows. Prerequisites: ECE 312, 340.

MAE 372 Fluid Mechanics. (3) A

Application of basic principles of fluid mechanics to problems in viscous and compressible flow. Prerequisites: ECE 384, 386; MAE 361 (or 371).

MAE 382 Thermodynamics. (3) A

Applied thermodynamics; gas mixtures, psychrometrics, property relationships, power and refrigeration cycles, and reactive systems. Prerequisite: ECE 340.

MAE 388 Heat Transfer. (3) F, S

Steady and unsteady heat conduction, including numerical solutions; thermal boundary layer concepts and applications to free and forced convection. Thermal radiation concepts. Prerequisite: MAE 361 or 371.

MAE 402 Introduction to Continuum Mechanics. (3) A

Application of the principles of continuum mechanics to such fields as flow-in porous media, biomechanics, electromagnetic continua, and magneto-fluid mechanics. Prerequisites: ECE 313; MAE 361 (or 371); MAT 242 (or 342).

MAE 404 Finite Elements in Engineering. (3) A

Introduction to ideas and methodology of finite element analysis. Applications to solid mechanics, heat transfer, fluid mechanics, and vibrations. Prerequisites: ECE 313; MAT 242 (or 342).

MAE 406 CAD/CAM Applications in MAE. (4) A

Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis, and manufacturing; selection of modeling parameters; reliability tests on software. 3 hours lecture, 3 hours lab. Prerequisites: MAE 441; instructor approval.

MAE 413 Aircraft Performance, Stability, and Control. (3) S

Aircraft performance, cruise, climbing and turning flights, energy maneuverability, 6 DOF equations for aircraft, aerodynamic stability derivatives, flight stability/control. Prerequisites: MAE 317, 361.

MAE 415 Vibration Analysis. (4) F, S

Free and forced response of single and multiple degree of freedom systems, continuous systems; applications in mechanical and aerospace systems numerical methods. Lecture, lab. Prerequisites: ECE 312; MAE 422 (or 425); MAT 242 (or 342).

MAE 417 Control System Design. (3) A

Tools and methods of control system design and compensation, including simulation, response optimization, frequency domain techniques, state variable feedback, and sensitivity analysis. Introduction to nonlinear and discrete time systems. Prerequisite: MAE 317.

MAE 422 Mechanics of Materials. (4) F, S

Failure theories, energy methods, finite element methods, plates, torsion of noncircular members, unsymmetrical bending, shear center, and beam column. Lecture, lab. Prerequisites: ECE 313; MAT 242 (or 342). Pre- or corequisite: ECE 386.

MAE 425 Aerospace Structures. (4) A

Stability, energy methods, finite element methods, torsion, unsymmetrical bending and torsion of multicelled structures, design of aerospace structures. Lecture, lab. Prerequisites: ECE 313; MAT 242 (or 342).

MAE 426 Design of Aerospace Structures. (3) A

Flight vehicle loads, design of semi-monocoque structures, local buckling and crippling, fatigue, aerospace materials, composites, joints, and finite element applications. Prerequisites: MAE 361, 425.

MAE 433 Air Conditioning and Refrigeration. (3) A

Air conditioning processes; environmental control; heating and cooling loads; psychrometry; refrigeration cycles. Prerequisite: MAE 388 or MET 432 or instructor approval.

MAE 434 Internal Combustion Engines. (3) A

Performance characteristics, combustion, carburetion and fuel-injection, and the cooling and control of internal combustion engines. Computer modeling. Lab. Prerequisite: MAE 388.

MAE 435 Turbomachinery. (3) A

Design and performance of turbomachines, including steam, gas and hydraulic turbines, centrifugal pumps, compressors, fans, and blowers. Pre- or corequisite: MAE 361 or 371.

MAE 436 Combustion. (3) A

Thermochemical and reaction rate processes; combustion of gaseous and condensed-phase fuels. Applications to propulsion and heating systems. Pollutant formation. Prerequisite: MAE 388.

MAE 441 Principles of Design. (3) F, S

Conceptual and embodiment design of mechanical elements; form synthesis; material selection, failure modes, manufacturability tolerances, common mechanisms, and machine elements. Lecture, lab (project). Prerequisites: ECE 300, 350. Pre- or corequisite: MAE 422 or 425.

MAE 442 Mechanical Systems Design. (3) A

Application of design principles and techniques to the synthesis, modeling, and optimization of mechanical, electromechanical, and hydraulic systems. Prerequisites: MAE 422 (or 425), 441.

MAE 443 Engineering Design. (3) F, S

Group projects to design engineering components and systems. Problem definition ideation, modeling, and analysis; decision making and documentation activities emphasized. 6 hours lab. Prerequisite: MAE 441.

MAE 444 Fundamentals of Aerospace Design. (3) S

Design theory and design tools applied to aerospace engineering. Engineering drawings, solid modeling, RFP's, Federal Aviation Regulations and military specifications, aircraft sizing, rapid prototyping. Lab, projects. Prerequisites: ECE 300; MAE 361, 425. Pre- or corequisite: MAE 413.

MAE 446 Thermal Systems Design. (3) A

Application of engineering principles and techniques to the modeling and analysis of thermal systems and components. Optimization techniques are presented and their use demonstrated. Prerequisite: ECE 300; MAE 388.

MAE 447 Robotics and Its Influence on Design. (3) A

Robot applications, configurations, singular positions, and work space; modes of control; vision; programming exercises; design of parts for assembly. Prerequisite: MAE 317.

MAE 455 Polymers and Composites. (3) F

Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MSE 470. Credit is allowed for only MAE 455 or MSE 470. Prerequisite: ECE 350.

MAE 460 Gas Dynamics. (3) A

Compressible flow at subsonic and supersonic speeds; duct flow; normal and oblique shocks, perturbation theory, and wind tunnel design. Prerequisites: ECE 386; MAE 361 (or 371).

MAE 461 Aerodynamics II. (3) A

Transonic/hypersonic flows, wing theory, Navier-Stokes, laminar/turbulent shear flows, pressure drop in tubes, separation, drag, viscous/inviscid interaction, and wing design. Prerequisite: MAE 460.

MAE 462 Space Vehicle Dynamics and Control. (3) F

Attitude dynamics and control, launch vehicles, orbital mechanics, orbital transfer/rendezvous, space mission design, space structures, spacecraft control systems design. Prerequisite: MAE 317.

MAE 463 Propulsion. (3) A

Fundamentals of gas-turbine engines and design of components. Principles and design of rocket propulsion and alternative devices. Lecture, design projects. Prerequisite: ECE 386. Pre- or corequisite: MAE 361 (or 371).

MAE 464 Aerospace Laboratory. (3) F, S

Aerodynamic flow parameters; flow over airfoils and bodies of revolution; flow visualization; computer-aided data acquisition and processing; boundary layer theory. 1 hour lecture, 4 hours lab. Prerequisites: ECE 386; MAE 361, 460.

MAE 465 Rocket Propulsion. (3) A

Rocket flight performance; nozzle design; combustion of liquid and solid propellants; component design; advanced propulsion systems; interplanetary missions; testing. Prerequisite: MAE 361 or 371.

MAE 466 Rotary Wing Aerodynamics and Performance. (3) A

Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressibility effects. Prerequisites: ECE 386 and MAE 361 or instructor approval.

MAE 467 Aircraft Performance. (3) A

Integration of aerodynamic and propulsive forces into aircraft performance design. Estimation of drag parameters for design. Engine, airfoil selection. Conceptual design methodology. Lecture, design projects. Prerequisite: MAE 361 or 371. Pre- or corequisite: MAE 441.

MAE 468 Aerospace Systems Design. (3) F, S

Group projects related to aerospace vehicle design, working from mission definition and continuing through preliminary design. Prerequisites: MAE 361, 413, 463. *General Studies: L2.*

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

MAE 469 Projects in Astronautics or Aeronautics. (3) F, S
Various multidisciplinary team projects available each semester. Projects include design of high-speed rotocraft autonomous vehicles, liquid-fueled rockets, micro-aerial vehicles, satellites. Prerequisite: instructor approval.

MAE 471 Computational Fluid Dynamics. (3) A
Numerical solutions for selected problems in fluid mechanics. Prerequisites: ECE 384; MAE 361 (or 371).

MAE 490 Projects in Design and Development. (3) F, S
Capstone projects in fundamental and applied aspects of engineering. Prerequisites: MAE 441, 491. *General Studies: L2.*

MAE 491 Experimental Mechanical Engineering. (3) F, S
Experimental and analytical studies of phenomena and performance of fluid flow, heat transfer, thermodynamics, refrigeration, and mechanical power systems. 6 hours lab. Prerequisites: EEE 350; MAE 388.

MAE 498 PS: Pro-Seminar. (1–3) N
Special topics for advanced students. Application of the engineering disciplines to design and analysis of modern technical devices and systems. Prerequisite: instructor approval.

MAE 504 Laser Diagnostics. (3) S
Fundamentals of optics and the interaction of light with matter. Laser sources, laser spectroscopy, velocimetry, particle sizing, and surface characterization.

MAE 505 Perturbation Methods. (3) N
Nonlinear oscillations, strained coordinates, renormalization, multiple scales, boundary layers, matched asymptotic expansions, turning point problems, and WKBJ method. Cross-listed as MAT 505. Credit is allowed for only MAE 505 or MAT 505.

MAE 506 Advanced System Modeling, Dynamics, and Control. (3) S
Lumped-parameter modeling of physical systems with examples. State variable representations and dynamic response. Introduction to modern control. Prerequisite: ASE 582 or MAT 442.

MAE 507 Optimal Control. (3) F
Optimal control of systems. Calculus of variations, dynamic programming, linear quadratic regulator, numerical methods, and Pontryagin's principle. Cross-listed as EEE 587. Credit is allowed for only EEE 587 or MAE 507. Prerequisite: EEE 482 or MAE 506.

MAE 509 Robust Multivariable Control. (3) S
Characterization of uncertainty in feedback systems, robustness analysis, synthesis techniques, multivariable Nyquist criteria, computer-aided analysis and design. Prerequisites: MAE 417, 506.

MAE 510 Dynamics and Vibrations. (3) F
Lagrange's and Hamilton's equations, rigid body dynamics, gyroscopic motion, and small oscillation theory.

MAE 511 Acoustics. (3) F
Principles underlying the generation, transmission, and reception of acoustic waves. Applications to noise control, architectural acoustics, random vibrations, and acoustic fatigue.

MAE 512 Random Vibrations. (3) S
Review of probability theory, random processes, stationarity, power spectrum, white noise process, random response of single and multiple DOF systems, and Markov processes simulation. Prerequisite: MAE 510 or instructor approval.

MAE 515 Structural Dynamics. (3) S
Free vibration and forced response of discrete and continuous systems, exact and approximate methods of solution, finite element modeling, and computational techniques. Prerequisite: MAE 510 or instructor approval.

MAE 517 Nonlinear Oscillations. (3) F
Existence, stability, and bifurcation of solutions of nonlinear dynamical systems. Methods of analysis of regular and chaotic responses. Prerequisite: MAE 510 or instructor approval.

MAE 518 Dynamics of Rotor-Bearing Systems. (3) S
Natural whirl frequency, critical speed, and response analysis of rigid and flexible rotor systems. Bearing influence and representation. Stability analysis. Methods of balancing.

MAE 520 Solid Mechanics. (3) F
Introduction to tensors: kinematics, kinetics, and constitutive assumptions leading to elastic, plastic, and viscoelastic behavior. Applications.

MAE 521 Structural Optimization. (3) N
Linear and nonlinear programming. Problem formulation. Constrained and unconstrained optimization. Sensitivity analysis. Approximate techniques. FEM-based optimal design of mechanical and aerospace structures. Cross-listed as CEE 533. Credit is allowed for only CEE 533 or MAE 521. Prerequisite: instructor approval.

MAE 522 Variational Principles of Mechanics. (3) S
Virtual work, stationary, and complementary potential energies. Hamilton's principle. Application of these and direct methods to vibrations, elasticity, and stability. Prerequisite: MAE 520 or equivalent.

MAE 523 Theory of Plates and Shells. (3) F
Linear and nonlinear theories of plates. Membrane and bending theories of shells. Shells of revolution. Prerequisite: MAE 520.

MAE 524 Theory of Elasticity. (3) S
Formulation and solution of 2- and 3-dimensional boundary value problems. Prerequisite: MAE 520.

MAE 527 Finite Element Methods in Engineering Science. (3) F
Discretization, interpolation, elemental matrices, assembly, and computer implementation. Application to solid and fluid mechanics, heat transfer, and time dependent problems. Prerequisite: ASE 582.

MAE 536 Combustion. (3) N
Thermodynamics; chemical kinetics of combustion. Explosion and ignition theories. Reactive gas dynamics. Structure, propagation, and stability of flames. Experimental methods. Prerequisite: MAE 436 or instructor approval.

MAE 540 Advances in Engineering Design Theory. (3) F
Survey of research in engineering design process, artifact and design, knowledge, formal and informal logic, heuristic and numerical searches, theory of structure and complexity. Prerequisite: graduate standing.

MAE 541 CAD Tools for Engineers. (3) F
Elements of computer techniques required to develop CAD software. Data structures, including lists, trees, and graphs. Computer graphics, including 2- and 3-dimensional algorithms and user interface techniques.

MAE 542 Geometric Modeling in CAD/CAM. (3) S
Geometric and solid modeling, curve and surface design, CAD database architectures, and integration of solid modeling into engineering processes. Prerequisite: MAE 541 or instructor approval.

MAE 544 Mechanical Design and Failure Prevention. (3) F
Modes of mechanical failure; application of principles of elasticity and plasticity in multiaxial state of stress to design synthesis; failure theories; fatigue; creep; impact. Prerequisite: MAE 443.

MAE 546 CAD/CAM Applications in MAE. (4) F
Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis; and manufacturing; selection of modeling parameters; reliability tests on software. Open only to students without previous credit for MAE 406. 3 hours lecture, 3 hours lab. Prerequisite: instructor approval.

MAE 547 Mechanical Design and Control of Robots. (3) N
Homogeneous transformations, 3-dimensional kinematics, geometry of motion, forward and inverse kinematics, workspace and motion trajectories, dynamics, control, and static forces.

MAE 548 Mechanism Synthesis and Analysis. (3) S
Algebraic and graphical methods for exact and approximate synthesis of cam, gear, and linkage mechanisms; design optimization; methods of planar motion analysis; characteristics of plane motion; spatial kinematics.

MAE 557 Mechanics of Composite Materials. (3) S
Analysis of composite materials and applications. Micromechanical and macromechanical behavior. Classical lamination theory developed with investigation of bending-extension coupling.

MAE 560 Propulsion Systems. (3) N
Design of air-breathing gas turbine engines for aircraft propulsion; mission analysis; cycle analysis; engine sizing; component design.

MAE 561 Computational Fluid Dynamics. (3) S
Finite-difference and finite-volume techniques for solving the subsonic, transonic, and supersonic flow equations. The method of characteristics. Numerical grid-generation techniques. Prerequisite: MAE 571 or instructor approval.

MAE 563 Unsteady Aerodynamics. (3) S
Unsteady incompressible and compressible flow. Wings and bodies in oscillatory and transient motions. Kernel function approach and panel methods. Aeroelastic applications. Prerequisite: MAE 460 or 461.

MAE 564 Advanced Aerodynamics. (3) F

Perturbation method. Linearized subsonic and supersonic flows. Thin wing/slender body theories. Lifting surface theory. Panel method computation. Prerequisite: MAE 460 or 461.

MAE 566 Rotary-Wing Aerodynamics. (3) F

Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressibility effects. Prerequisite: MAE 361.

MAE 571 Fluid Mechanics. (3) F

Basic kinematic, dynamic, and thermodynamic equations of the fluid continuum and their application to basic fluid models.

MAE 572 Inviscid Fluid Flow. (3) S

Mechanics of fluids for flows in which the effects of viscosity may be ignored. Potential flow theory, waves, and inviscid compressible flows. Prerequisite: MAE 571.

MAE 573 Viscous Fluid Flow. (3) F

Mechanics of fluids for flows in which the effects of viscosity are significant. Exact and approximate solutions of the Navier-Stokes system, laminar flow at low and high Reynolds number. Prerequisite: MAE 571.

MAE 575 Turbulent Shear Flows. (3) F

Homogeneous, isotropic, and wall turbulence. Experimental results. Introduction to turbulent-flow calculations. Prerequisite: MAE 571.

MAE 577 Turbulent Flow Modeling. (3) S

Reynolds equations and their closure. Modeling of simple and complex turbulent flows, calculations of internal and external flows, and application to engineering problems. Prerequisite: MAE 571.

MAE 581 Thermodynamics. (3) F

Basic concepts and laws of classical equilibrium thermodynamics; applications to engineering systems. Introduction to statistical thermodynamics.

MAE 582 Statistical Thermodynamics. (3) A

Kinetic and quantum theory. Statistical mechanics; ensemble theory. Structure and thermodynamics of noninteracting and interacting particles. Boltzmann integro-differential equation. Prerequisite: graduate standing.

MAE 585 Conduction Heat Transfer. (3) F

Basic equations and concepts of conduction heat transfer. Mathematical formulation and solution (analytical and numerical) of steady and unsteady, one- and multidimensional heat conduction and phase change problems. Prerequisites: ECE 386; MAE 388.

MAE 586 Convection Heat Transfer. (3) S

Basic concepts and governing equations. Analysis of laminar and turbulent heat transfer for internal and external flows. Natural and mixed convection. Prerequisite: MAE 388.

MAE 587 Radiation Heat Transfer. (3) F

Advanced concepts and solution methodologies for radiation heat transfer, including exchange of thermal radiation between surfaces, radiation in absorbing, emitting, and scattering media and radiation combined with conduction and convection. Prerequisite: MAE 388.

MAE 588 Two-Phase Flows and Boiling Heat Transfer. (3) S

Pool and flow boiling heat transfer, condensation heat transfer, various models of vapor-liquid mixture flows, gas-solid mixture flows, and experimental measurement techniques.

MAE 589 Heat Transfer. (3) F

Basic concepts; physical and mathematical models for heat transfer. Applications to conductive, convective, radiative, and combined mode heat transfer. Prerequisite: MAE 388.

MAE 594 Graduate Research Conference. (1) F, S

Topics in contemporary research. Required every semester of all departmental graduate students registered for 9 or more semester hours. Not for degree credit.

MAE 598 ST: Special Topics. (1–3) F, S

Special topics courses, including the following, which are regularly offered, are open to qualified students:

- (a) Advanced Spacecraft Control
- (b) Aeroelasticity
- (c) Aerospace Vehicle Guidance and Control
- (d) Boundary Layer Stability
- (e) Hydrodynamic Stability
- (f) Plasticity
- (g) Polymers and Composites

Programs in Engineering Special Studies

Daniel F. Jankowski

Director

The programs leading to the B.S.E. degree in Engineering Special Studies are administered by the Dean of the College of Engineering and Applied Sciences.

PURPOSE

The major of Engineering Special Studies accommodates students whose educational objectives require more intensity of concentration on a particular subject or more curricular flexibility within an engineering discipline than the traditional departmental majors generally permit. The major is a School of Engineering program. Unlike the departmental major areas, however, there is not a separate faculty. The faculty teaching and advising in these programs are from the various departments within the School of Engineering.

For many students, engineering studies form the basis of preparation for professional engineering work where proficiency in the application of science and the physical and social technologies is brought to bear on problems of a large scope. The necessary breadth that these students seek often is not obtainable in traditional engineering fields. Rather, specially designed programs of course work that merge the required principles and approaches drawn from all fields of engineering and other pertinent disciplines are desired.

The B.S.E. degree in Engineering Special Studies is designed primarily for students intending to pursue engineering careers at a professional level in industry or graduate studies.

ENGINEERING SPECIAL STUDIES—B.S.E.

Premedical Engineering. In the past decade, the interrelation between engineering and medicine has become vigorous and exciting. Our rapidly expanding technology dictates that engineering will continue to become increasingly involved in all branches of medicine. As this develops, so will the need for physicians trained in the engineering sciences—medical men and women with a knowledge of computer technology, transport phenomena, biomechanics, bioelectric phenomena, operations research, and cybernetics. This option is of special interest to students desiring entry into a medical college and whose medical interests lie

NOTE: For the General Studies requirement, courses, and codes (such as L1, N3, C, and H), see "General Studies," page 85. For graduation requirements, see "University Graduation Requirements," page 81. For an explanation of additional omnibus courses offered but not listed in this catalog, see "Classification of Courses," page 58.

in research, aerospace and undersea medicine, artificial organs, prostheses, biomedical engineering, or biophysics. Since both engineering and medicine have as their goal the well-being of humans, this program is compatible with any field of medical endeavor.

Academic Requirements. The following courses are required in the premedical engineering option and have been selected to meet all university and school requirements.

Note: To fulfill medical school admission requirements, BIO 182 General Biology is also required in addition to the degree requirements and is best taken in summer session before the Medical College Admission Test (MCAT).

First-Year Composition

Choose among the course combinations below	6
ENG 101 First-Year Composition (3)	
ENG 102 First-Year Composition (3)	
-----or-----	
ENG 105 Advanced First-Year Composition (3)	
Elective chosen with an advisor (3)	
-----or-----	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles <i>SB</i> ¹	3
or ECN 112 Microeconomic Principles <i>SB</i> ¹ (3)	
HU, SB, and awareness area courses ²	13
Total	16

Literacy and Critical Inquiry

BME 413 Biomedical Instrumentation <i>L2</i>	3
BME 423 Biomedical Instrumentation Laboratory <i>L2</i>	1
ECE 300 Intermediate Engineering Design <i>L1</i>	3
Total	7

Natural Sciences

PHY 121 University Physics I: Mechanics <i>S1/S2</i> ³	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ³	1
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ⁴	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ⁴	1
Total	8

Numeracy/Mathematics

ECE 100 Introduction to Engineering Design <i>N3</i>	4
MAT 242 Elementary Linear Algebra	2
or ECE 384 Numerical Analysis for Engineers I (2)	
or ECE 386 Partial Differential Equations for Engineers (2)	
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
MAT 274 Elementary Differential Equations <i>N1</i>	3
Total	21
General Studies/school requirements total	52

Engineering Core

ECE 210 Engineering Mechanics I: Statics	3
ECE 301 Electrical Networks I	4
ECE 334 Electronic Devices and Instrumentation	4
ECE 340 Thermodynamics	3

ECE 350 Structure and Properties of Materials	3
Total	17

Engineering Special Studies Program Major—

Premedical Engineering Option

BIO 181 General Biology <i>S1/S2</i>	4
BME 201 Introduction to Bioengineering <i>L1</i>	3
BME 318 Biomaterials	3
BME 335 Biomedical Engineering Transport I: Fluids	3
BME 334 Bioengineering Heat and Mass Transfer	3
BME 416 Biomechanics	3
BME 417 Biomedical Engineering Capstone Design I	3
BME 435 Physiology for Engineers	4
BME 470 Microcomputer Applications in Bioengineering	4
BME 490 Biomedical Engineering Capstone Design II	3
CHM 113 General Chemistry <i>S1/S2</i>	4
CHM 116 General Chemistry <i>S1/S2</i>	4
CHM 331 General Organic Chemistry	3
CHM 332 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory	1
CHM 336 General Organic Chemistry Laboratory	1
ECE 380 Probability and Statistics for Engineering Problem Solving <i>N2</i>	3
Technical elective	1
Total	53

¹ ECN 111 or ECN 112 must be included to fulfill the HU and SB requirements.

² Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

³ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

⁴ Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

Premedical Engineering Program of Study Typical Four-Year Sequence

First Year

First Semester

CHM 113 General Chemistry <i>S1/S2</i>	4
ECE 100 Introduction to Engineering Design <i>N3</i>	4
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>N1</i>	4
Total	15

Second Semester

CHM 116 General Chemistry <i>S1/S2</i>	4
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II <i>N1</i>	4
PHY 121 University Physics I: Mechanics <i>S1/S2</i> ¹	3
PHY 122 University Physics Laboratory I <i>S1/S2</i> ¹	1
Total	15

Second Year

First Semester

BIO 181 General Biology <i>S1/S2</i>	4
BME 201 Introduction to Bioengineering <i>L1</i>	3
ECE 210 Engineering Mechanics I: Statics	3
MAT 272 Calculus with Analytic Geometry III <i>N1</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>S1/S2</i> ²	3
PHY 132 University Physics Laboratory II <i>S1/S2</i> ²	1
Total	18

Second Semester

CHM 331 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory	1

ECE 301 Electrical Networks I	4
ECE 350 Structure and Properties of Materials	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Macroeconomic Principles <i>SB</i> (3)	
MAT 274 Elementary Differential Equations <i>NI</i>	3
Total	17

Third Year

First Semester

BME 331 Biomedical Engineering Transport I: Fluids	3
BME 435 Physiology for Engineers	4
CHM 332 General Organic Chemistry	3
ECE 300 Intermediate Engineering Design <i>L1</i>	3
ECE 340 Thermodynamics.....	3
Total	16

Second Semester

BME 318 Biomaterials	3
BME 334 Bioengineering Heat and Mass Transfer.....	3
CHM 336 General Organic Chemistry Laboratory.....	1
ECE 334 Electronic Devices and Instrumentation	4
MAT 242 Elementary Linear Algebra <i>NI</i>	2
or ECE 384 Numerical Analysis for Engineers I (2)	
or ECE 386 Partial Differential Equations	
for Engineers (2)	
HU, SB, and awareness area course(s) ³	4
Total	17

Fourth Year

First Semester

BME 413 Biomedical Instrumentation <i>L2</i>	3
BME 416 Biomechanics	3
BME 417 Biomedical Engineering Capstone Design I.....	3
BME 423 Biomedical Instrumentation Laboratory <i>L2</i>	1
HU, SB, and awareness area courses ³	6
Total	16

Second Semester

BME 470 Microcomputer Applications in Bioengineering.....	4
BME 490 Biomedical Engineering Capstone Design II.....	3
ECE 380 Probability and Statistics for Engineering Problem	
Solving <i>N2</i>	3
HU, SB, and awareness area course ³	3
Technical elective.....	1
Total	14
Degree requirements total	128

¹ Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

² Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.