
Ira A. Fulton School of Engineering

www.fulton.asu.edu

Peter E. Crouch, Ph.D., Dean

Del E. Webb School of Construction	215
Engineering Programs	219
Harrington Department of Bioengineering	223
Department of Chemical and Materials Engineering	228
Department of Civil and Environmental Engineering	236
Department of Computer Science and Engineering	242
Department of Electrical Engineering	248
Department of Industrial Engineering	252
Department of Mechanical and Aerospace Engineering	256
Programs in Engineering Special Studies	264

PURPOSE

The purpose of the Ira A. Fulton School of Engineering 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, entrepreneurship, life-long learning, and responsible participation as a member of society.

For more information, access the school's Web site at www.fulton.asu.edu.

ORGANIZATION

The Fulton School of Engineering is composed of the following academic units:

- Del E. Webb School of Construction
- Department of Chemical and Materials Engineering
- Department of Civil and Environmental Engineering
- Department of Computer Science and Engineering
- Department of Electrical Engineering
- Department of Industrial Engineering
- Department of Mechanical and Aerospace Engineering
- Harrington Department of Bioengineering

Research Centers. The school is committed to the development of research programs of national prominence and to the concept that research is an important part of its educa-

tional role. The school encourages the participation of 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 academic units listed under "Organization," on this page, and in the following interdisciplinary research institutes and centers:

- Arizona BioDesign Institute
- Center for Low Power Electronics
- Center for Research on Education in Science, Mathematics, Engineering, and Technology
- Center for Solid State Electronics Research
- Institute for Computing and Information Science and Engineering
- Institute for Manufacturing Enterprise Systems
- Institute for Studies in the Arts

Center for Professional Development. As a service unit of the Ira A. Fulton School of Engineering, the Center for Professional Development (CPD) offers engineering and technical professionals the skills and knowledge necessary to master new methods, lead projects and teams, and to advance professionally. By leveraging the nationally renowned faculty in the Fulton School of Engineering and affiliate experts, CPD offers online master's degree programs. The programs allow students with complex schedules to complete graduate degrees from remote locations. They complete the same requirements and receive the same degree that students do on campus. CPD also administers short courses and conferences, professional certification programs, and customized programs at company sites. For more information, call 480/965-1740, or access the center's Web site at www.asuengineeringonline.com.

ADMISSION

Individuals wishing to be admitted to freshman standing in the Fulton School of Engineering should have completed certain secondary-school units. These units are identified in

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

Professional Status Requirements

Student	Program	High School Rank	ABOR GPA	Minimum Scores		Transfer GPA*	
				ACT	SAT	Resident	Nonresident
Resident	Construction	Upper 25%	3.00	23	1140	—	—
	Engineering	Upper 25%	3.00	23	1140	—	—
Nonresident	Construction	Upper 25%	3.00	24	1140	—	—
	Engineering	Upper 25%	3.00	24	1140	—	—
Transfer	Construction	—	—	—	—	2.25	2.50
	Engineering	—	—	—	—	2.50	2.50

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

the text that follows. If these conditions are not met, additional university course work, possibly unacceptable for degree credit, may be required.

Entrance requirements of this school 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” table, on this page. In addition, students who are required to take the Test of English as a Foreign Language (TOEFL) must earn a score of at least 550 (230 on the computerized version).

Students admitted to the university after successful completion of the General Education Development 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, on this page.

For Computer Science and Computer Systems Engineering professional status requirements, see “Admission Requirements,” page 242.

Preprofessional Status. In the Fulton School of Engineering, there are two versions of *preprofessional status*. One applies to a school-level preprofessional status; the conditions associated with the school of engineering preprofessional status are described in the following material. The second version is of concern only to students interested in pursuing majors within the Department of Computer Science and Engineering (CSE); for descriptive material on the CSE preprofessional status, see “Department of Computer Science and Engineering,” page 242, or access the CSE Web site at cse.asu.edu.

A student not admissible to professional status within the school but otherwise regularly admissible to ASU as stated in “Undergraduate Admission,” page 65, may be admitted as a *preprofessional* student to any one of the academic programs of the school. 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. Preprofessional students are not permitted to register for 300- and 400-level courses in this school until the student’s status is changed to professional.

Readmission. Students applying for readmission to professional status for any program in this school must have a cumulative GPA for all college course work equal to that of the transfer admission requirements shown in the “Professional Status Requirements” table, on this page.

Transfer into and Within the School. Students transferring between academic programs within the school or from other colleges or schools 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 who have been in continuous attendance may continue under the catalog in effect at the time of their entrance into the community college. See “Guidelines for Determination of Catalog Year,” page 87.

Transfer Students. A student who contemplates transferring into this school 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 school 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 school.

The minimum requirements for admission of resident, nonresident, and transfer students to the professional program are shown in the “Professional Status Requirements” table, on this page. The academic units may impose additional admission and graduation requirements beyond the minimum specified by the school.

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” (2.00) are accepted as transfer credit to meet the graduation requirements of this school. 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 degree programs, prospective Arizona transfer stu-

Ira A. Fulton School of Engineering Baccalaureate Degrees and Majors

Major	Degree	Concentration ¹	Administered By
Aerospace Engineering ²	B.S.E.	—	Department of Mechanical and Aerospace Engineering
Bioengineering ²	B.S.E.	—	Harrington Department of Bioengineering
Chemical Engineering ²	B.S.E.	—	Department of Chemical and Materials Engineering
Civil Engineering ²	B.S.E.	Construction engineering or environmental engineering	Department of Civil and Environmental Engineering
Computer Science ²	B.S.	Optional: software engineering ¹	Department of Computer Science and Engineering
Computer Systems Engineering ²	B.S.E.	—	Department of Computer Science and Engineering
Construction ²	B.S.	General building construction, heavy construction, residential construction, or specialty construction	Del E. Webb School of Construction
Electrical Engineering ²	B.S.E.	—	Department of Electrical Engineering
Engineering Interdisciplinary Studies ³	B.S.	—	Ira A. Fulton School of Engineering
Engineering Special Studies ²	B.S.E.	Optional: premedical engineering ¹	Ira A. Fulton School of Engineering and the Harrington Department of Bioengineering
Industrial Engineering ²	B.S.E.	—	Department of Industrial Engineering
Materials Science and Engineering ²	B.S.E.	—	Department of Chemical and Materials Engineering
Mechanical Engineering ²	B.S.E.	—	Department of Mechanical and Aerospace Engineering

¹ If a major offers concentrations, one must be selected unless noted as *optional*.

² This major requires a minimum of 128 semester hours to complete.

³ Applications for this program are not being accepted at this time.

dents should consult their advisors and refer to the ASU transfer tools available on the Web at www.asu.edu/provost/articulation.

It should be noted that some courses taken in other ASU colleges or other universities may be acceptable for general university credit but may not be applicable toward the degree requirements of this school. Determination of those particular courses applicable to a specific degree program is made within the appropriate academic unit with the approval of the dean.

ADVISING

For assistance and counseling in planning a program of study, each student in this school 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 to avoid academic problems.

Students enrolled in an undergraduate degree program in this school may register for a maximum of 19 semester hours each semester. Any student wanting to register for more than the maximum must submit a petition and have an approval on file before registering for the overload.

Students who are enrolled in an undergraduate nondegree status in this school must obtain advising and approval to register before registering each semester from the director of Student Academic Services. For more information, see “Admission of Undergraduate Nondegree Applicants,” page 71.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Ira A. Fulton School of Engineering Graduate Degrees and Majors

Major	Degree	Concentration ¹	Administered By
Aerospace Engineering	M.S., M.S.E., Ph.D.	—	Department of Mechanical and Aerospace Engineering
Bioengineering	M.S., Ph.D.	—	Harrington Department of Bioengineering
Chemical Engineering	M.S., M.S.E., Ph.D.	—	Department of Chemical and Materials Engineering
Civil Engineering	M.S., M.S.E., Ph.D.	—	Department of Civil and Environmental Engineering
Computer Science	M.C.S.	—	Department of Computer Science and Engineering
	M.S., Ph.D.	Optional: arts, media, and engineering ¹	Department of Computer Science and Engineering
Construction	M.S.	Construction science, facilities, or management	Del E. Webb School of Construction
Electrical Engineering	M.S., Ph.D.	Optional: arts, media, and engineering ¹	Department of Electrical Engineering
	M.S.E.	—	Department of Electrical Engineering
Engineering	M.Eng.	—	Ira A. Fulton School of Engineering
Engineering Science	M.S., Ph.D.	—	Ira A. Fulton School of Engineering
	M.S.E.	Optional: executive embedded systems ¹	Ira A. Fulton School of Engineering
Industrial Engineering	M.S., M.S.E., Ph.D.	—	Department of Industrial Engineering
Materials Engineering	M.S., M.S.E.	—	Department of Chemical and Materials Engineering
Materials Science	M.S. ²	—	Committee on the Science and Engineering of Materials
Mechanical Engineering	M.S., M.S.E., Ph.D.	—	Department of Mechanical and Aerospace Engineering
Science and Engineering of Materials	Ph.D. ²	High-resolution nanostructure analysis or solid-state device materials design	Committee on the Science and Engineering of Materials

¹ If a major offers concentrations, one must be selected unless noted as *optional*.

² This program is administered by the Graduate College.

UNDERGRADUATE DEGREES

The faculty in the Fulton School of Engineering offer programs leading to the B.S. and B.S.E. degrees with majors in the subjects shown in the “Ira A. Fulton School of Engineering Baccalaureate Degrees and Majors” table, page 211. Each major is administered by the academic unit indicated.

Integrated B.S.E.-M.S. Program. To provide greater program flexibility, qualified engineering students 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 DEGREES

The faculty in the Fulton School of Engineering offer master’s and doctoral degrees as shown in the “Ira A. Fulton School of Engineering Graduate Degrees and Majors” table, on this page. Engineering faculty participate in offering the Master of Engineering (M.Eng.) as a collaborative degree program offered by Arizona’s three state universities. For more information, see the *Graduate Catalog*.

ASU EXTENDED CAMPUS

The College of Extended Education was created in 1990 to extend the resources of ASU throughout Maricopa County, the state, and beyond. The College of Extended Education is a university-wide college that oversees the

ASU Extended Campus and forms partnerships with other ASU colleges, including the Fulton School of Engineering, to meet the instructional and informational needs of a diverse community.

The ASU Extended Campus goes beyond the boundaries of the university's physical campuses to provide access to quality academic credit and degree programs for working adults through flexible schedules; a vast network of off-campus sites; classes scheduled days, evenings, and weekends; and innovative delivery technologies including television, the Internet, and Independent Learning. The Extended Campus also offers a variety of professional continuing education and community outreach programs.

For more information, see "ASU Extended Campus," page 689, or access the Web site at www.asu.edu/xed.

UNDERGRADUATE DEGREE REQUIREMENTS

For detailed information on the degree requirements of a major in the Ira A. Fulton School of Engineering, refer to that academic unit'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 87). 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 94, in the course descriptions in this catalog or on the Web, in the *Schedule of Classes*, and in the *Summer Sessions Bulletin*. Consult with an 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" (2.00) or higher is required for graduation from ASU in any baccalaureate program as described in "First-Year Composition Requirement," page 87. 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.

DEGREE REQUIREMENTS

Pass/Fail Grades

Students enrolled in the school do not receive degree credit for pass/fail courses taken at this institution. In addition, no course in this school 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 to the department of their major. 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 in this school 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 school'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 academic units have certain additional requirements that must be met in addition to the above school requirements, and students should consult them for details.

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

Currency of Course Work

Courses taken more than five years before admission to degree programs in this school 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.

ACADEMIC STANDARDS

Probation. A student is expected to make satisfactory progress toward completion of degree requirements to continue enrollment in the school. 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

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

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 director of Student Academic Services. Any disqualified student who is accepted by another college or school at ASU may not register for courses in this school unless the courses are required for the new major. Disqualified students who do register for courses in this school may be withdrawn from these courses any time during that semester. Furthermore, students at the university who have been disqualified academically by this school are not eligible to enroll in summer session courses in this school until the disqualification period has expired and they have been reinstated.

Reinstatement. The school does not accept an application for reinstatement until the disqualified student has remained out of this school 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 a GPA of 2.50 or higher, and a cumulative GPA of 2.50 or higher for all courses completed.

Student Academic Services. The Ira A. Fulton School of Engineering maintains a unit to assist individual students in various matters. This office coordinates the work of the Academic Standards Committee; administers the probation, disqualification, and readmission processes, student disciplinary actions, and grade grievances; and reviews and processes requests for medical and compassionate withdrawal. This office also administers the school's scholarship program. Additional information is available at www.fulton.asu.edu/sas.

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 consent 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 "Withdrawals," page 81, and does not count against the number of restricted withdrawals allowed.

SPECIAL OPPORTUNITIES

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 school 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 and the dean of the school.

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, visit Student Academic Services, or call 480/965-1750, and visit the Career Services office in SSV 329, or call 480/965-2350.

Honor Societies. Students 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 school:

Alpha Eta Mu Beta—Bioengineering Honor Society
Alpha Pi Mu—Industrial Engineering Honor Society
Chi Epsilon—Civil Engineering Honor Society
Eta Kappa Nu—Electrical Engineering Honor Society
Omega Rho—Industrial Engineering 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.

Honors Students. The Fulton School of Engineering participates in the programs of the Barrett 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 can be found in "The Barrett Honors College," page 128.

Internships. A variety of internship programs exist within the college. Information on these programs can be obtained from the Engineering Internship Program coordinator in the office of the associate dean for Academic Affairs.

Scholarships. Information and applications for academic scholarships for continuing students may be obtained by contacting Student Academic Services or the various department or school offices. Other scholarships may be available through the university Student Financial Assistance Office. For application and more information, access the Web site at www.fulton.asu.edu/sas.

ROTC. Students pursuing a commission through either the Air Force or Army ROTC programs are required to take courses in the Department of Aerospace Studies or Depart-

ment 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 school.

GENERAL INFORMATION

Definition of Terms. The terms used 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 Study (Technical Electives) 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 several majors, the technical electives must be chosen from preselected groups. For this reason the choice of specific technical electives for an area of study should be made with the advice and counsel of an advisor. Example: major—Mechanical Engineering; area of study—thermosciences.

Del E. Webb School of Construction

construction.asu.edu
 480/965-3615
 USE 138

William W. Badger, Director

Professor: Badger

Associate Professors: Ariaratnam, Bashford, Chasey, Ernzen, Kashiwagi, Sawhney, Weber, Wiezel

Assistant Professors: Fiori, Knutson, Martin

Visiting Eminent Scholar: Schleifer

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 concentrations to suit individual backgrounds, aptitudes, and objectives. These concentrations are not absolute but generally match major divisions of the construction industry.

DEGREES

Construction—B.S.

The faculty in the Del E. Webb School of Construction offer the B.S. degree in Construction. Four concentrations are available: general building construction, heavy construction, residential construction, and specialty construction.

Each concentration 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 courses, technical courses basic to engineering and construction, and courses on a broad range of applied management subjects fundamental to the business of construction contracting.

Construction—M.S.

The faculty in the school also offer the M.S. degree in Construction. 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.

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.

Student Organizations. The school has a chapter of Sigma Lambda Chi, 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 student chapter, the National Association of Home Builders student chapter, and the Construction Women’s Alliance.

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.

Business Minor. The school, in conjunction with the W. P. Carey School of Business, offers a business minor for

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

students who have an interest in additional business courses while pursuing a degree in construction. The courses available for the minor are designed to appeal to and inform the nonbusiness student. Courses cover a broad range of topics important to modern managers. See a construction undergraduate advisor for minor requirements.

ADMISSION

For information regarding requirements for admission, transfer, retention, qualification, and reinstatement, see “Undergraduate Admission,” page 65; “Admission,” page 209; and “Degree Requirements,” page 213. 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 87) 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. Participation in a summer field internship activity is required for all students between the second and third years of the program.

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 general building construction, heavy construction, residential construction, and specialty construction. Students in all concentrations 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” (2.00) 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 “General Studies,” page 91, and all university graduation requirements as noted in “University Graduation Requirements,” page 87. Note that all three General Studies awareness areas are required. Consult an advisor for an approved list of courses.

SCHOOL COURSE REQUIREMENTS

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

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i>	
CON 101 Construction and Culture: A Built Environment <i>HU, G, H</i>	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
ECN 112 Macroeconomic Principles <i>SB</i>	3
HU/SB and awareness area course as needed	3
HU/SB (upper division) and awareness area course as needed	3
Total	15
<i>Literacy and Critical Inquiry</i>	
COM 225 Public Speaking <i>L</i>	3
CON 496 Construction Contract Administration	3
Total	6
<i>Natural Sciences</i>	
PHY 111 General Physics <i>SQ</i> ¹	3
PHY 112 General Physics <i>SQ</i> ²	3
PHY 113 General Physics Laboratory <i>SQ</i> ¹	1
PHY 114 General Physics Laboratory <i>SQ</i> ²	1
Total	8
<i>Mathematical Studies</i>	
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
STP 226 Elements of Statistics <i>CS</i>	3
Total	7
General Studies/school requirements total ³	36

¹ Both PHY 111 and 113 must be taken to secure SQ credit.

² Both PHY 112 and 114 must be taken to secure SQ 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 Concentrations

(Except as Noted)	
ACC 230 Uses of Accounting Information I	3
or ACC 394 ST: Financial Analysis and Accounting for Small Businesses (3)*	
CEE 340 Hydraulics and Hydrology	3
CON 221 Applied Engineering Mechanics: Statics	3
CON 223 Strength of Materials	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 296 Field Internship	0
CON 310 Testing of Materials for Construction	3
CON 341 Surveying	3
CON 345 Mechanical Systems	3
CON 371 Construction Management and Safety	3
CON 383 Construction Estimating	4
CON 389 Construction Cost Accounting and Control <i>CS</i>	3
CON 424 Structural Design	3
CON 450 Soil Mechanics in Construction	3
CON 453 Construction Labor Management	3
CON 455 Construction Project Management	3
CON 463 Foundations	3
CON 495 Construction Planning and Scheduling <i>CS</i>	3
ECE 100 Introduction to Engineering Design <i>CS</i>	3
LES 305 Legal, Ethical, and Regulatory Issues in Business	3
or LES 306 Business Law (3) (ASU West)	
or LES 380 Consumer Perspective of Business Law (3)	

Physical science elective with lab	4
Total common to all concentrations	71

* ACC 394 ST: Financial Analysis and Accounting for Small Businesses is recommended.

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 all concentrations.

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 <i>MA</i>	4
PHY 111 General Physics <i>SQ</i> ¹	3
PHY 113 General Physics Laboratory <i>SQ</i> ¹	1
Total	17

Second Semester

ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECN 112 Microeconomic Principles <i>SB</i>	3
ENG 102 First-Year Composition	3
PHY 112 General Physics <i>SQ</i> ²	3
PHY 114 General Physics Laboratory <i>SQ</i> ²	1
HU elective with awareness area as needed	3
Total	16

Third Semester

CON 221 Applied Engineering Mechanics: Statics	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>CS</i>	3
Total	15

Fourth Semester

ACC 230 Uses of Accounting Information I..... or ACC 394 ST: Financial Analysis and Accounting for Small Businesses ³ (3)	3
COM 225 Public Speaking <i>L</i>	3
CON 223 Strength of Materials.....	3
CON 252 Building Construction Methods, Materials, and Equipment	3
Physical science elective with lab	4
Total	16

¹ Both PHY 111 and 113 must be taken to secure SQ credit.
² Both PHY 112 and 114 must be taken to secure SQ credit.
³ ACC 394 ST: Financial Analysis and Accounting for Small Businesses is recommended.

Concentration in General Building Construction

The general building construction concentration 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 industrial, 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>L</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 380 Real Estate Fundamentals	3
Upper-division technical elective	3
Total	15

Concentration in Heavy Construction

The heavy construction concentration 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 earth-work.

Requirements

CON 484 Managerial Internship	3
CON 486 Heavy Construction Estimating	3
Upper-division business electives	6
Upper-division technical elective	3
Total	15

Concentration in Residential Construction

The residential construction concentration prepares students for careers in the residential sector of the industry. This concentration 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
CON 484 Internship	3
MKT 382 Advertising and Marketing Communication.....	3
PUP 432 Planning and Development Control Law	3
or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes (3)	
Total	15

Concentration in Specialty Construction

The specialty construction concentration prepares students for careers with specialty constructors, such as mechanical and electrical construction firms. It emphasizes the construction process at the trade contractor level.

Requirements

CON 468 Mechanical and Electrical Estimating	3
CON 471 Mechanical and Electrical Project Management.....	3
CON 494 ST: Cleanroom Construction	3
Upper-division business electives	6
Total	15

L literacy and critical inquiry / *MA* mathematics / *CS* computer/statistics/quantitative applications / *HU* humanities and fine arts / *SB* social and behavioral sciences / *SG* natural science—general core courses / *SQ* natural science—quantitative / *C* cultural diversity in the United States / *G* global / *H* historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

CONSTRUCTION (CON)

CON 101 Construction and Culture: A Built Environment. (3)

fall and spring

Analyzes 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.

General Studies: HU, G, H

CON 221 Applied Engineering Mechanics: Statics. (3)

fall and spring

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 223 Strength of Materials. (3)

fall and spring

Analyzes strength and rigidity of structural members in resisting applied forces. Stress, strain, shear, moment, deflections, combined stresses, connections, and moment distribution. Both U.S. and SI units of measurement. Prerequisite: CON 221.

CON 243 Heavy Construction Equipment, Methods, and Materials. (3)

fall and spring

Emphasizes "Horizontal" construction. Fleet operations, maintenance programs, methods, and procedures to construct tunnels, roads, dams, and the excavation of buildings. Lab, field trips. Fee.

CON 251 Microcomputer Applications for Construction. (3)

fall and spring

Applies the microcomputer as a problem-solving tool for the constructor. Uses spreadsheets, information management, and multimedia software. Prerequisite: ECE 100.

CON 252 Building Construction Methods, Materials, and Equipment. (3)

fall and spring

Emphasizes "Vertical" construction. Methods, materials, codes, and equipment used in building construction corresponding to the 16 division "Master Format." Lecture, lab. Fee.

CON 273 Electrical Construction Fundamentals. (3)

fall and spring

Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Lecture, field trips. Prerequisites: PHY 112, 114.

CON 296 Field Internship. (0)

summer

Participation as interns on construction projects to observe and experience the daily activities. Internship.

CON 310 Testing of Materials for Construction. (3)

fall and spring

Structural and behavioral characteristics, engineering properties, measurements, and application of construction materials. Not open to engineering students. Lecture, lab. Fee. Prerequisite: CON 223.

CON 341 Surveying. (3)

fall, spring, summer

Theory and field work in construction and land surveys. Lecture, lab. Cross-listed as CEE 381. Credit is allowed for only CEE 381 or CON 341. Fee. Prerequisite: MAT 270.

CON 345 Mechanical Systems. (3)

fall and spring

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)

fall and spring

Organization and management theory applied to the construction process. Leadership functions. Safety procedures and equipment. OSHA requirements for construction. Prerequisite: CON 252.

CON 377 Residential Construction Production Procedures. (3)

spring

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. (4)

fall and spring

Analyzes construction drawings and specifications. Methods used in estimating process. Quantity surveying techniques for CSI divisions. Lecture, project workshops. Prerequisites: CON 243, 252.

CON 389 Construction Cost Accounting and Control. (3)

fall and spring

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 Businesses); CON 251.

General Studies: CS

CON 424 Structural Design. (3)

fall

Economic use of concrete, steel, and wood in building and engineered structures. Design of beams, columns, concrete formwork, and connections. Lecture, field trips. Prerequisite: CON 310.

CON 450 Soil Mechanics in Construction. (3)

fall and spring

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. Fee. Prerequisite: CON 223.

CON 453 Construction Labor Management. (3)

fall and spring

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. Fee. Prerequisites: CON 371; ECN 112.

CON 455 Construction Project Management. (3)

fall and spring

Study of methods for coordinating people, equipment, materials, money, and schedule to complete a project on time and within approved cost. Lecture, class projects, CPC exam. Fee. Prerequisite: CON 371. Pre- or corequisite: CON 495.

CON 463 Foundations. (3)

spring

Subsurface construction theory and practice for description, excavations, exploration, foundations, pavements, and slopes. Evaluation of specifications and plans of work. Lecture, recitation, field trips. Prerequisite: CON 450.

CON 468 Mechanical and Electrical Estimating. (3)

fall

Analysis and organization of performing a cost estimate for both mechanical and electrical construction projects. Computer usage. Prerequisites: a combination of CON 273 and 345 and 383 or only instructor approval.

CON 471 Mechanical and Electrical Project Management. (3)

spring

Specialty contracts and agreements, scheduling, material handling, labor unit analysis, and job costing for mechanical and electrical construction. Prerequisite: CON 371.

CON 472 Development Feasibility Reports. (3)

fall and spring

Integrates economic location theory, development cost data, market research data, and financial analysis into a feasibility report. Computer orientation. Prerequisite: REA 380.

General Studies: L

CON 477 Residential Construction Business Practices. (3)

fall

Topics addressed include development, marketing, financing, legal issues, and sales.

CON 483 Advanced Building Estimating. (3)

fall and spring

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 484 Internship. (1–12)

fall, spring, summer

Structured practical experience following a contract or plan, supervised by faculty and practitioners. May serve with industry participant

or government agency. May be repeated for credit. Topics may include the following:

- Managerial Internship. (3)
Prerequisites: CON 296; school approval.

CON 486 Heavy Construction Estimating. (3)

fall

Methods analysis and cost estimation for construction of highways, bridges, tunnels, dams, and other engineering works. May be repeated for credit. Lecture, field trips. Prerequisites: CON 341, 383.

CON 492 Honors Directed Study. (1–6)

selected semesters

CON 493 Honors Thesis. (1–6)

selected semesters

CON 494 Special Topics. (1–4)

fall and spring

Topics may include the following:

- Cleanroom Construction. (3)
fall

CON 495 Construction Planning and Scheduling. (3)

fall and spring

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. Fee. Prerequisites: CON 383; STP 226. Pre- or corequisite: CON 389.

General Studies: CS

CON 496 Construction Contract Administration. (3)

fall and spring

Surveys administrative procedures of general and subcontractors. Studies documentation, claims, arbitration, litigation, bonding, insurance, and indemnification. Discusses ethical practices. Lecture, field trips. Prerequisites: COM 225 or ECE 300; senior standing.

CON 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see “Omnibus Courses,” page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see “Graduate-Level Courses,” page 62.

Engineering Programs

480/965-1726

PURPOSE

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 preengineering 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

For information regarding requirements for admission, transfer, retention, disqualification, and reinstatement, see “Undergraduate Admission,” page 65; “Admission,” page 209; “Degree Requirements,” page 213; and “Academic Standards,” page 213.

Individuals who are beginning their initial college work in engineering should have completed certain secondary school units in addition to the minimum university admission 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 also recommended. Students who do not meet 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 180 Computer Literacy, CSE 181 Applied Problem Solving with Visual BASIC, MAT 170 Precalculus, and PHY 105 Basic Physics—may be required to satisfy omissions or deficiencies upon admission.

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 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, Accreditation Board for Engineering and Technology, Inc. (ABET), for programs in engineering and computing science, respectively.

In addition to First-Year Composition, the university requires, through the General Studies requirement, courses in literacy and critical inquiry, humanities and fine arts, social and behavioral sciences, mathematical studies, and natural sciences (see “General Studies,” page 91). There are

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

also requirements for historical awareness, global awareness, and cultural diversity in the United States. ABET imposes 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 to 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 program types: (1) those associated with a particular program (for example, Electrical Engineering and Civil Engineering) and (2) those offered as concentrations 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 study. These credits are traditionally referred to as *technical electives*.

Majors and areas of study are offered by the seven engineering departments within the Fulton School of Engineering:

Department of Chemical and Materials Engineering
 Department of Civil and Environmental Engineering
 Department of Computer Science and Engineering
 Department of Electrical Engineering
 Department of Industrial Engineering
 Department of Mechanical and Aerospace Engineering
 Harrington Department of Bioengineering

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 concentrations not available in the traditional engineering curricula at ASU.

The first two years of engineering 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 or professional advisor. See the "Typical Freshman Year" table, on this page, an example for a full-time student; depending on a particular student's circumstances, many other examples are possible.

Typical Freshman Year

CHM 114	General Chemistry for Engineers <i>SQ</i>	4 or 8
	or CHM 113 General Chemistry <i>SQ</i> (4)	
	and CHM 116 General Chemistry <i>SQ</i> (4)	
ECE 100	Introduction to Engineering Design <i>CS</i>	3
ECN 111	Macroeconomic Principles <i>SB</i>	3
	or ECN 112 Microeconomic Principles <i>SB</i> (3)	
ENG 101	First-Year Composition	3
ENG 102	First-Year Composition	3
MAT 270	Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271	Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121	University Physics I: Mechanics <i>SQ</i> *.....	3
PHY 122	University Physics Laboratory I <i>SQ</i> *.....	1
	HU/SB and awareness area course.....	3
Total	.....	31 or 35

* Both PHY 121 and 122 must be taken to secure *SQ* 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 courses 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 87), and the literacy and critical inquiry component (see "Five Core Areas," page 91) of the university 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, mathematical studies, 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 university 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 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.....	56
Engineering core*	14–18
Major (including area of study or concentration)*	48–52
Minimum total	128

* The requirements for each of the majors offered are described in the department sections.

Specific course requirements for the B.S. and B.S.E. degrees follow.

First-Year Composition

Choose among the course combinations below6

- 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)

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

Total6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences¹

- ECN 111 Macroeconomic Principles *SB*
- or ECN 112 Macroeconomic Principles *SB* (3)

HU and awareness area courses 6 or 9
 SB and awareness area course(s) 3 or 6

Total15

Literacy and Critical Inquiry

- ECE 300 Intermediate Engineering Design *L*
- ECE 400 Engineering Communications.....

Total6

Mathematical, Computation, and Quantitative Studies

- ECE 100 Introduction to Engineering Design *CS*
- MAT 270 Calculus with Analytic Geometry I *MA*
- MAT 271 Calculus with Analytic Geometry II *MA*
- MAT 272 Calculus with Analytic Geometry III *MA*
- MAT 274 Elementary Differential Equations *MA*
- Department mathematics elective

Total20

Natural Sciences/Basic Sciences

- CHM 114 General Chemistry for Engineers *SQ*.....
- or CHM 116 General Chemistry *SQ* (4)
- PHY 121 University Physics I: Mechanics *SQ*²
- PHY 122 University Physics Laboratory I *SQ*²
- PHY 131 University Physics II: Electricity and Magnetism *SQ*³
- PHY 132 University Physics Laboratory II *SQ*³
- Department basic science elective

Total15

General Studies/school requirements total.....56

¹ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Courses in the awareness areas of global, historical, and cultural diversity in the United States must also be represented in the program of study. One course must be upper-division.
² Both PHY 121 and 122 must be taken to secure *SQ* credit.
³ Both PHY 131 and 132 must be taken to secure *SQ* credit.

Engineering Core Requirement

In addition to ECE 100 and 300, which also fulfill a portion of the university General Studies requirement, a minimum of five of the following eight courses are required. Courses selected are subject to departmental approval. See department requirements.

- ECE 201 Electrical Networks I
- ECE 210 Engineering Mechanics I: Statics.....
- ECE 212 Engineering Mechanics II: Dynamics.....
- ECE 214 Engineering Mechanics.....
- ECE 313 Introduction to Deformable Solids.....
- ECE 334 Electronic Circuits

L literacy and critical inquiry / *MA* mathematics / *CS* computer/statistics/quantitative applications / *HU* humanities and fine arts / *SB* social and behavioral sciences / *SG* natural science—general core courses / *SQ* natural science—quantitative / *C* cultural diversity in the United States / *G* global / *H* historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

- ECE 340 Thermodynamics.....3
or CHE 342 Applied Chemical Thermodynamics (4)
or MSE 430 Thermodynamics of Materials (3)
- ECE 350 Structure and Properties of Materials3
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 CS (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 CS (3)

GRADUATION REQUIREMENTS

To qualify for graduation, a student must have a minimum cumulative ASU 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 ABET, Baltimore, Maryland, 410/347-7700. The B.S. program in Computer Science is accredited by the Computer Science Accreditation Commission of ABET.

ANALYSIS AND SYSTEMS (ASE)

ASE 100 College Adjustment and Survival. (2)

fall and spring

Explores career goals and majors. Emphasizes organization and development of study skills, including time management, stress management, and use of the library.

ASE 194 Special Topics. (1-4)

fall

Topics may include the following:

- MEP Academic Success. (2)
- MEP Computer Basics. (1)

ASE 399 Cooperative Work Experience. (1)

fall, spring, summer

Work periods with industrial firms or government agencies alternated with full-time course work. Not open to students from other colleges. May be repeated for credit. Prerequisites: 45 hours completed in major with 2.50 GPA; dean approval.

ASE 490 Project in Design and Development. (2-3)

fall, spring, summer

Individual project in creative design and synthesis. May be repeated for credit. Prerequisite: senior standing.

ASE 496 Professional Seminar. (0)

fall and spring

Topics of interest to students in the engineering special and interdisciplinary studies.

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students

may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

ENGINEERING CORE (ECE)

ECE 100 Introduction to Engineering Design. (3)

fall and spring

Introduces engineering design; teaming; the profession of engineering; computer models in engineering; communication skills; quality and customer satisfaction. Credit is allowed for only ECE 100 or 200. Fee. Prerequisites: high school computing and physics and algebra courses (or their equivalents).

General Studies: CS

ECE 200 Elements of Engineering Design. (3)

fall and spring

Advanced version of ECE 100 for students who transfer to ASU after completion of the stated prerequisites. Credit is allowed for only ECE 200 or 100. Lecture, lab. Prerequisites for engineering majors: ENG 101 (or 105); MAT 270; PHY 121, 122. Prerequisites for Construction majors: ENG 101 (or 105); MAT 270; PHY 111, 113. Pre- or corequisite for engineering majors: CHM 113 or 114 or 116.

General Studies: CS

ECE 201 Electrical Networks I. (4)

fall, spring, summer

Fundamental network theorems for dc and ac analysis. Utilization of SPICE. Design and measurement of linear analog electrical systems. Lecture, lab. Fee. Prerequisite: ECE 100 or 200. Pre- or corequisites: MAT 274 (or 275); PHY 131, 132.

ECE 210 Engineering Mechanics I: Statics. (3)

fall, spring, summer

Force systems, resultants, equilibrium, distributed forces, area moments, fluid statics, internal stresses, friction, energy criterion for equilibrium, and stability. Lecture, recitation. Prerequisites: ECE 100 (or 200); MAT 271 (or 291); PHY 121, 122.

ECE 212 Engineering Mechanics II: Dynamics. (3)

fall, spring, summer

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 214 Engineering Mechanics. (4)

fall, spring, summer

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 (or 200); MAT 274; PHY 121, 122.

ECE 300 Intermediate Engineering Design. (3)

fall, spring, summer

Engineering design process concentrating on increasing the ability to prepare well-written technical communication and to define problems and generate and evaluate ideas. Teaming skills enhanced. Fee. Prerequisites: ECE 100 (or 200); ENG 102 (or 105 or 108); at least two other engineering core courses.

General Studies: L

ECE 313 Introduction to Deformable Solids. (3)

fall, spring, summer

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 (or 214); MAT 274.

ECE 334 Electronic Circuits. (4)

fall, spring, summer

Applies electric network theory to semiconductor circuits. Diodes/transistors/amplifiers/opamps/digital logic gates, and electronic instruments. Lecture, lab. Fee. Prerequisite: ECE 201.

ECE 340 Thermodynamics. (3)

fall, spring, summer

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 (or 214); PHY 131, 132. Pre- or corequisite: MAT 274.

ECE 350 Structure and Properties of Materials. (3)*fall, spring, summer*

Basic concepts of material structure and its relation to properties. Application to engineering problems. Prerequisites: CHM 114 (or 116); PHY 121, 122.

ECE 351 Civil Engineering Materials. (3)*fall and spring*

Structure and behavior of civil engineering materials. Laboratory investigations and test criteria. Lecture, lab. Fee. Prerequisite: ECE 313.

ECE 352 Properties of Electronic Materials. (4)*fall, spring, summer*

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 362; PHY 241.

ECE 380 Probability and Statistics for Engineering Problem Solving. (3)*fall and spring*

Applications-oriented course with computer-based experience using statistical software for formulating and solving engineering problems. 2 hours lecture, 2 hours lab. Fee. Prerequisite: MAT 271.

*General Studies: CS***ECE 384 Numerical Methods for Engineers. (4)***fall and spring*

Numerical methods and computational tools for selected problems in engineering. Prerequisites: ECE 100 (or 200); MAT 274; at least two other engineering core courses. Pre- or corequisite: MAT 272.

ECE 400 Engineering Communications. (3)*fall, spring, summer*

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 L requirement (or ECE 300); senior standing in an engineering major.

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

SOCIETY, VALUES, AND TECHNOLOGY (STE)**STE 208 Patterns in Nature. (4)***fall and spring*

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

General Studies: SQ

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Harrington Department of Bioengineering

www.fulton.asu.edu/~bme

480/965-3028

ECG 334

Eric J. Guilbeau, Chair**Olin Endowed Professor:** Guilbeau**Professors:** He, Towe**Associate Professors:** Abbas, Garcia, Iasemidis, Joshi, Jung, Massia, Pizziconi, Sweeney**Assistant Professors:** Caplan, Muthuswamy, Panitch, Vernon**Affiliated Faculty:** Kim, Kozicki, Macia, Santello**Research Professors:** Brophy, Herman, Khairallah, Yamaguchi**Research Associate Professor:** Singh**Research Assistant Professors:** Helms Tillery, Shimansky**Senior Research Professional:** Brandon**Research Scientists:** Coursen, Ehteshami, Pauken

The faculty in the Harrington Department of Bioengineering offer the B.S.E. degree in Bioengineering. The major builds on a broad base of knowledge within the basic and mathematical sciences and the engineering core. The major offers graduates excellent career opportunities.

Faculty within the department also participate in the Engineering Special Studies program in premedical engineering, which is described separately in "Programs in Engineering Special Studies," page 264.

BIOENGINEERING—B.S.E.

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. The mission of the bioengineering program at ASU is to educate students to use engineering and scientific principles and methods to develop instrumentation, materials, diagnostic and therapeutic devices, artificial organs, or other equipment and technologies needed in medicine and biology and to discover new fundamental princi-

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

ples regarding the functioning and structure of living systems. The overall goal of the program is to produce high-quality graduates with a broad-based education in engineering and the life and natural sciences who are well prepared for further graduate study in bioengineering, a career in the medical device or biotechnology industries, a career in biomedical research, or entry into a medical or other health profession school.

The program's mission is achieved by having its faculty and graduate teachers fulfill the following objectives: to provide students with a strong foundation in mathematics, the physical and life sciences, and basic engineering; and to give students a balance of theoretical understanding and ability in order to apply modern techniques, skills, and tools for problem solving at the interface of engineering with the biological and medical sciences. Students demonstrate an ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and nonliving materials and systems. Students are able to design systems, devices, components, processes, and experiments with an understanding of manufacturing processes to meet real-world needs for solutions to problems in the biomedical device industries, medicine, and the life sciences. Students are able to communicate effectively as bioengineers in oral, written, computer-based, and graphical forms. Faculty seek to instill students with a sense of commitment to professionalism and ethical responsibility as bioengineers. Students are given opportunities to interact with and gain real-world experience with local and national medical device and technology industries, health-care organizations, educational institutions, and constituent populations. Faculty seek to develop within students an understanding of and positive approach toward continued lifelong learning of new technologies and relevant issues in the discipline of bioengineering.

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

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Bioengineering. A minimum of 50 upper-division semester hours is required. Students must attain a GPA of at least 2.00 for the courses in the major field.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 87.

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 below6

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)

Total6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles *SB*3

or ECN 112 Microeconomic Principles *SB* (3)

HU/SB and awareness area courses12

Total15

Literacy and Critical Inquiry

BME 413 Biomedical Instrumentation *L*3

BME 423 Biomedical Instrumentation Laboratory *L*1

ECE 300 Intermediate Engineering Design *L*3

Total7

Natural Sciences/Basic Sciences

CHM 113 General Chemistry *SQ*4

CHM 116 General Chemistry *SQ*4

PHY 121 University Physics I: Mechanics *SQ*¹3

PHY 122 University Physics Laboratory I *SQ*¹1

PHY 131 University Physics II: Electricity and

Magnetism *SQ*²3

PHY 132 University Physics Laboratory II *SQ*²1

Total16

Mathematical Studies

ECE 100 Introduction to Engineering Design *CS*3

ECE 384 Numerical Methods for Engineers4

MAT 270 Calculus with Analytic Geometry I *MA*4

MAT 271 Calculus with Analytic Geometry II *MA*4

MAT 272 Calculus with Analytic Geometry III *MA*4

MAT 274 Elementary Differential Equations *MA*3

Total22

General Studies/school requirements total60

Engineering Core

ECE 201 Electrical Networks I4

ECE 214 Engineering Mechanics4

ECE 334 Electronic Circuits4

ECE 340 Thermodynamics3

ECE 350 Structure and Properties of Materials3

Total18

Major

BIO 188 General Biology II *SQ*4

BME 101 Introduction to Bioengineering3

BME 235 Physiology for Engineers4

BME 318 Biomaterials3

BME 331 Biomedical Engineering Transport: Fluids3

BME 350 Signals and Systems for Bioengineers3

BME 417 Biomedical Engineering Capstone Design I3

BME 470 Microcomputer Applications in Bioengineering4

BME 490 Biomedical Engineering Capstone Design II3

CSE 100 Principles of Programming with C++ *CS*³3

ECE 380 Probability and Statistics for Engineering

Problem Solving *CS*3

Technical electives8

Total44

¹ Both PHY 121 and 122 must be taken to secure *SQ* credit.

² Both PHY 131 and 132 must be taken to secure *SQ* credit.

³ CSE 110 Principles of Programming with Java can be substituted for CSE 100 with departmental approval.

The major BME courses require a grade of “C” (2.00) or higher to advance in the program and to receive a baccalaureate degree.

Bioengineering Areas of Study

Technical electives should in general be selected from one of the following emphasis areas. Students can elect to emphasize biochemical engineering, bioelectrical engineering, biomaterials engineering, biomechanical engineering, biomedical imaging engineering, biosystems engineering, molecular and cellular bioengineering, or premedical engineering in their studies. A student may also, with prior approval of the department, select a general area of study or combination of courses that support a career in bioengineering not covered by the following areas.

Biochemical Engineering. This area is designed to strengthen the student’s knowledge of chemistry and transport phenomena and is particularly well suited for students interested in biotechnology. Students must take the following course:

BME 334 Bioengineering Heat and Mass Transfer.....	3
--	---

Students should choose additional technical electives from the following:

BCH 361 Principles of Biochemistry.....	3
or BCH 461 General Biochemistry (3)	
BCH 462 General Biochemistry	3
CHE 475 Biochemical Engineering.....	3
CHE 476 Bioreaction Engineering	3
CHE 477 Bioseparation Processes.....	3
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
MIC 420 Immunology: Molecular and Cellular Foundations.....	3

Bioelectrical Engineering. This area is designed to strengthen the student’s knowledge of electrical systems, electronics, and signal processing. Students considering a career in bioelectric phenomena, biocontrol systems, medical instrumentation, neural engineering, or electrophysiology should consider this area of study. Students should choose technical electives from the following:

BME 419 Biocontrol Systems	3
EEE 302 Electrical Networks II	3
EEE 425 Digital Systems and Circuits.....	4
EEE 433 Analog Integrated Circuits.....	4

Biomaterials Engineering. This area 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 consider this area of study. Students must take the following two courses:

MSE 353 Introduction to Materials Processing and Synthesis.....	3
MSE 355 Introduction to Materials Science and Engineering.....	3

Students should choose additional technical electives from the following:

BME 334 Bioengineering Heat and Mass Transfer.....	3
BME 494 ST: Biopolymeric Drug Delivery	3
MSE 431 Corrosion and Corrosion Control.....	3
MSE 441 Analysis of Material Failures.....	3
MSE 470 Polymers and Composites.....	3
MSE 471 Introduction to Ceramics.....	3

Biomechanical Engineering. This area is designed to strengthen the student’s knowledge of mechanics and control theory. Students interested in careers related to biomechanical analyses, the design of orthotic/prosthetic devices and orthopaedic implants, forensic biomechanics, and rehabilitation engineering should consider this area of study. While students may choose any combination of the following technical electives, it is recommended that courses be selected from one of three subareas: movement biomechanics, rehabilitation engineering, or orthopaedic biomechanics. The movement biomechanics area is designed to strengthen the student’s knowledge of dynamics and control theory. Students interested in analyzing pathological movement disorders, sports techniques, and neuromuscular control should select courses from this area. Rehabilitation engineering emphasizes the design of highly functional products for people with disabilities. Biomechanical, electrical, and mechanical design procedures are used to develop new assistive devices, orthoses, and prostheses. The student primarily interested in the material properties of bones, cartilage, soft tissues, and the design of implants for tissue repair and replacement should select courses from the orthopaedic biomechanics area. Students must take the following course:

BME 416 Biomechanics	3
----------------------------	---

Recommended subarea selections are as follows:

Movement Biomechanics

BME 419 Biocontrol Systems	3
KIN 334 Functional Anatomy and Kinesiology	3
KIN 414 Electromyographic Kinesiology L	3

Rehabilitation Engineering

IEE 437 Human Factors Engineering	3
or DSC 344 Human Factors in Design (3)	
IND 354 Principles of Product Design	3
KIN 334 Functional Anatomy and Kinesiology	3
MAE 341 Mechanism Analysis and Design	3

Orthopaedic Biomechanics

ECE 313 Introduction to Deformable Solids.....	3
KIN 412 Biomechanics of the Skeletal System.....	3
MAE 404 Finite Elements in Engineering.....	3

Biomedical Imaging Engineering. This area is designed to strengthen the student’s knowledge of radiation interactions, health physics, medical diagnostic imaging (MRI, PET,

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

X-ray, CT), radiation protection, and nuclear instrumentation. Students considering careers in medical engineering or health physics should consider this area of study. Students should choose technical electives from the following or other departmental approved electives:

BME 494 ST: Scanning Probe Microscopy.....	3
EEE 460 Nuclear Concepts for the 21st Century.....	3
PHY 361 Introductory Modern Physics.....	3

Biosystems Engineering. This area 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 require 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 study.

Students should choose technical electives from the following (or other departmental approved electives):

BME 411 Biomedical Engineering I.....	3
BME 412 Biomedical Engineering II.....	3
BME 415 Biomedical Transport Processes.....	3
BME 419 Biocontrol Systems.....	3
CHE 476 Bioreaction Engineering.....	3

Molecular and Cellular Bioengineering. This area 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 biotechnologies.

Students are strongly encouraged to choose from the following courses:

BIO 353 Cell Biology.....	3
BME 334 Bioengineering Heat and Mass Transfer.....	3
CHM 331 General Organic Chemistry.....	3

Students should choose additional or alternative technical electives from the following:

BCH 361 Principles of Biochemistry.....	3
or BCH 461 General Biochemistry (3)	
BIO 340 General Genetics.....	4
or MBB 350 Applied Genetics (4)	
or PLB 350 Applied Genetics (4)	
BIO 343 Genetic Engineering and Society <i>L</i>	4
or MBB 343 Genetic Engineering and Society <i>L</i> (4)	
BME 494 ST: Cell Biotechnology.....	3
BME 494 ST: Introduction to Molecular, Cellular, and Tissue Engineering.....	3
CHE 475 Biochemical Engineering.....	3
or CHE 476 Bioreaction Engineering (3)	
or CHE 477 Bioseparation Processes (3)	
CHM 335 General Organic Chemistry Laboratory.....	1

Premedical Engineering. This area 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

Additional technical electives should be chosen from any of the course offerings listed for the other bioengineering areas of study listed. Note that, to fulfill medical school admission requirements, BIO 187 General Biology is required in addition to the degree requirements and cannot generally be used as a technical elective.

Bioengineering Program of Study Typical Four-Year Sequence

First Year

First Semester

CSE 100 Principles of Programming with C++ CS ¹	3
ECE 100 Introduction to Engineering Design CS.....	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total.....	13

Second Semester

BME 101 Introduction to Bioengineering.....	3
CHM 113 General Chemistry <i>SQ</i>	4
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ²	3
PHY 122 University Physics Laboratory I <i>SQ</i> ²	1
Total.....	18

Second Year

First Semester

BIO 188 General Biology II <i>SQ</i>	4
CHM 116 General Chemistry <i>SQ</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ³	3
PHY 132 University Physics Laboratory II <i>SQ</i> ³	1
Total.....	16

Second Semester

BME 235 Physiology for Engineers.....	4
ECE 201 Electrical Networks I.....	4
ECE 350 Structure and Properties of Materials.....	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
MAT 274 Elementary Differential Equations <i>MA</i>	3
Total.....	17

Third Year

First Semester

BME 318 Biomaterials.....	3
ECE 214 Engineering Mechanics.....	4
ECE 300 Intermediate Engineering Design <i>L</i>	3
ECE 384 Numerical Methods for Engineers.....	4
HU/SB and awareness area course ⁴	3
Total.....	17

Second Semester

BME 331 Biomedical Engineering Transport: Fluids.....	3
BME 350 Signals and Systems for Bioengineers.....	3
ECE 334 Electronic Circuits.....	4
ECE 340 Thermodynamics.....	3

HU/SB and awareness area course ⁴	3
Total	16

Fourth Year

First Semester

BME 413 Biomedical Instrumentation L ⁵	3
BME 417 Biomedical Engineering Capstone Design I.....	3
BME 423 Biomedical Instrumentation Laboratory L ⁵	1
ECE 380 Probability and Statistics for Engineering Problem Solving CS	3
HU/SB and awareness area course ⁴	3
Technical elective(s).....	3
Total	16

Second Semester

BME 470 Microcomputer Applications in Bioengineering.....	4
BME 490 Biomedical Engineering Capstone Design II.....	3
HU/SB and awareness area course ⁴	3
Technical electives	5
Total	15
Total degree requirements	128

- ¹ CSE 110 Principles of Programming with Java can be substituted for CSE 100 with departmental approval.
- ² Both PHY 121 and 122 must be taken to secure SQ credit.
- ³ Both PHY 131 and 132 must be taken to secure SQ credit.
- ⁴ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.
- ⁵ Both BME 413 and 423 must be taken to secure L credit.

BIOENGINEERING (BME)

BME 101 Introduction to Bioengineering. (3)

fall and spring

Impact of bioengineering on society. Develops an awareness of the contributions of bioengineering to solve medical and biological problems. Fee. Pre- or corequisites: ENG 102 (or 105 or 108); BME major (or department approval).

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

selected semesters

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 (or 105).

General Studies: L/HU

BME 235 Physiology for Engineers. (4)

fall

Physiology of the nervous, muscular, cardiovascular, endocrine, renal, and respiratory systems. Emphasizes use of quantitative methods in understanding physiological systems. Lecture, lab. Fee. Prerequisites: BIO 188; CHM 115 (or 116). Pre- or corequisite: PHY 131.

BME 318 Biomaterials. (3)

spring

Material properties of natural and artificial biomaterials. Tissue and blood biocompatibility. Uses of materials to replace body parts. Prerequisites: BIO 188; ECE 350.

BME 331 Biomedical Engineering Transport: Fluids. (3)

fall

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

BME 334 Bioengineering Heat and Mass Transfer. (3)

spring

Applies 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" (2.00) or higher: BME 331.

BME 350 Signals and Systems for Bioengineers. (3)

spring

Applies principles of calculus and ordinary differential equations to modeling and analysis of responses, signals, and signal transfers in biosystems. Prerequisites: ECE 201; MAT 272, 274.

BME 411 Biomedical Engineering I. (3)

once a year

Reviews diagnostic and prosthetic methods using engineering methodology. Introduces transport, metabolic, and autoregulatory processes in the human body. Prerequisite with a grade of "C" (2.00) or higher: BME 334.

BME 412 Biomedical Engineering II. (3)

once a year

Reviews electrophysiology and nerve pacing applications. Introduces 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)

fall

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" (2.00) or higher: BME 235. Corequisite: BME 423.

General Studies: L (if credit also earned in BME 423)

BME 415 Biomedical Transport Processes. (3)

once a year

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)

fall

Mechanical properties of bone, muscle, and soft tissue. Static and dynamic analysis of human movement tasks such as locomotion. Prerequisite: ECE 210 or 214. Prerequisite with a grade of "C" (2.00) or higher: BME 318.

BME 417 Biomedical Engineering Capstone Design I. (3)

fall

Technical, regulatory, economic, legal, social, and ethical aspects of medical device systems engineering design. Lecture, field trips. Prerequisites: BME 101; ECE 300. Pre- or corequisites with a grade of "C" (2.00) or higher: at least 5 of the 7 following courses: BME 318, 331, 350, 413, 470; ECE 340, 380.

BME 419 Biocontrol Systems. (3)

fall

Applies linear and nonlinear control systems techniques to analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body. Prerequisites: ECE 201; MAT 274.

BME 423 Biomedical Instrumentation Laboratory. (1)

fall

Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Fee. Prerequisites: ECE 300, 334. Prerequisite with a grade of "C" (2.00) or higher: BME 235. Corequisite: BME 413.

General Studies: L (if credit also earned in BME 413)

BME 451 Cell Biotechnology Laboratory. (3)

fall

Mammalian cell culture techniques, including mouse embryonic stem cells, the use of bioreactors, cell fractionation, and digital video imaging. Lab. Cross-listed as BIO 451. Credit is allowed for only BME 451 or BIO 451. Prerequisites: BIO 353; instructor approval.

BME 470 Microcomputer Applications in Bioengineering. (4)

spring

Uses microcomputers for real-time data collection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Fee. Prerequisite: ECE 334. Prerequisite with a grade of "C" (2.00) or higher: BME 235. BME 413 and 423 recommended.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

BME 490 Biomedical Engineering Capstone Design II. (1–5) *spring*

Individual projects in medical systems or medical device design and development. Lecture, lab. Fee. Prerequisite with a grade of "C" (2.00) or higher: BME 417.

BME 492 Honors Directed Study. (1–6) *selected semesters*

BME 493 Honors Thesis. (1–6) *selected semesters*

BME 494 Special Topics. (1–4) *selected semesters*

Topics may include the following:

- Biopolymeric Drug Delivery. (3)
- Biotechnology Laboratory Techniques. (3)
- Cell Biotechnology. (3)
Fee.
- Introduction to Molecular, Cellular, and Tissue Engineering. (3)
- Scanning Probe Microscopy. (3)

BME 496 Professional Seminar. (1–3)

fall and spring

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

BME 499 Individualized Instruction. (1–3) *selected semesters*

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Department of Chemical and Materials Engineering

www.fulton.asu.edu/~cme

480/965-3313

ECG 202

Subhash Mahajan, Chair

Regents' Professor: Mayer

Professors: Adams, Alford, Dey, Krause, Mahajan, Newman, Picraux, Raupp, Sieradzki

Associate Professors: Beckman, Burrows, Chawla, Rivera, Sierks, Van Schilfgaarde

Assistant Professors: Allen, Dillner, Park, Razatos

The faculty in the Department of Chemical and Materials Engineering offer the B.S.E. degree in Chemical Engineering and in 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.

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.

CHEMICAL ENGINEERING—B.S.E.

Chemical engineers are generally concerned with transfer within and between liquid, gas, and solid phases and the chemical changes that may also occur. The engineers 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.

The chemical engineering faculty are committed to fully developing the potential of the students by providing a unique learning environment that encourages the students to

DEPARTMENT OF CHEMICAL AND MATERIALS ENGINEERING

take responsibility for their education; exposes the students to a diversity of viewpoints and teaching/learning styles; prepares the students to work in teams to solve real-world, multidisciplinary problems; and sets them on a path of life-long learning. The faculty demand high quality work. They are fair, honest, courteous, and professional. They are sensitive to students' needs and dedicated to student success. They are interested in capitalizing on the nontraditional student demographics, including cultural background, age group, and the full- and part-time employed, to develop a vibrant and flexible education and research environment.

To achieve this commitment, the following program educational objectives were established by the chemical engineering faculty:

1. Graduates will have a strong foundation in mathematics, science, and engineering with a balance of theoretical understanding and ability to apply modern techniques, skills, and tools to solve real-world chemical engineering problems.
2. Graduates will have the skills and experience necessary to design component systems and processes for the manufacturing of chemical engineering products.
3. Graduates will have the skills and experience necessary to communicate effectively in oral, written, and graphical forms to various types of audiences.
4. Graduates will have the skills necessary to perform as engineers in a professional and ethical manner.
5. Graduates will have the skills and attitudes for continued life-long learning of new technologies and concepts.
6. Graduates will have opportunities to interact with local industries, educational institutions, and constituent populations.

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. Students must attain a GPA of at least 2.00 for the courses in the major field.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 87.

COURSE REQUIREMENTS

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 below6

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)

Total6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles *SB*3

or ECN 112 Microeconomic Principles *SB* (3)

HU/*SB* and awareness area courses¹12

Total15

Literacy and Critical Inquiry

CHE 462 Process Design *L*3

ECE 300 Intermediate Engineering Design *L*3

Total6

Natural Sciences/Basic Sciences

CHM 113 General Chemistry *SQ*4

CHM 116 General Chemistry *SQ*4

CHM 331 General Organic Chemistry3

CHM 335 General Organic Chemistry Laboratory1

PHY 121 University Physics I: Mechanics *SQ*²3

PHY 122 University Physics Laboratory I *SQ*²1

PHY 131 University Physics II: Electricity and

Magnetism *SQ*³3

Total19

Mathematical Studies

ECE 100 Introduction to Engineering Design *CS*3

ECE 384 Numerical Methods for Engineers4

MAT 270 Calculus with Analytic Geometry I *MA*4

MAT 271 Calculus with Analytic Geometry II *MA*4

MAT 272 Calculus with Analytic Geometry III *MA*4

MAT 274 Elementary Differential Equations *MA*3

Total22

General Studies/school requirements total62

Engineering Core

CHE 311 Introduction to Chemical Processing3

CHE 342 Applied Chemical Thermodynamics4

CHE 461 Process Control *CS*4

ECE 350 Structure and Properties of Materials3

ECE Core elective3

Total17

Major

CHE 331 Transport Phenomena I: Fluids3

CHE 334 Transport Phenomena II: Heat and Mass Transfer4

CHE 352 Transport Laboratories2

CHE 432 Principles of Chemical Engineering Design2

CHE 433 Modern Separations3

CHE 442 Chemical Reactor Design3

CHE 451 Chemical Engineering Laboratory2

CHM 332 General Organic Chemistry3

ECE 380 Probability and Statistics for Engineering

Problem Solving *CS*3

¹ L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Technical electives	18
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 SQ credit.

³ Both PHY 131 and 132 must be taken to secure SQ credit.

Students should consult with their department academic advisors 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.

Chemical Engineering Areas of Study

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 with suggested courses. A student may choose electives within the general department guidelines and does not have to select one of the areas listed.

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

BCH 361 Principles of Biochemistry.....	3
or BCH 461 General Biochemistry (3)	
BCH 462 General Biochemistry	3

Technical Electives

CHE 475 Biochemical Engineering.....	3
CHE 476 Bioreaction Engineering	3
CHE 477 Bioreparation Processes.....	3
CHE 494 ST: Biotechnology Techniques	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

BCH 361 Principles of Biochemistry.....	3
or BCH 461 General Biochemistry (3)	
BCH 462 General Biochemistry	3

Technical Electives

BME 318 Biomaterials	3
----------------------------	---

Environmental. Students interested in environmental engineering are encouraged to pursue a B.S.E. degree in Chemi-

cal Engineering with this area of study. Students interested in the management of hazardous wastes and air and water pollution should select from the following:

Chemistry Electives

BCH 361 Principles of Biochemistry.....	3
or BCH 461 General Biochemistry (3)	
CHM 302 Environmental Chemistry	3
CHM 481 Geochemistry	3
CHM 494 ST: Chemistry of Global Climate Change	3

Technical Electives

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

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 345 Physical Chemistry I.....	3
CHM 346 Physical Chemistry II.....	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.....	2
MSE 431 Corrosion and Corrosion Control.....	3
MSE 470 Polymers and Composites.....	3

Premedical. Students planning to attend medical school should select courses from those listed under the biomedical area. In addition, BIO 187, 188, 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:

CHE 474 Chemical Engineering Design for the Environment	3
CHE 478 Industrial Water Quality Engineering	3
CHE 494 ST: Advanced Process Control.....	3
MAE 436 Combustion	3

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

Chemistry Electives

CHM 345 Physical Chemistry I.....	3
CHM 346 Physical Chemistry II.....	3
CHM 453 Inorganic Chemistry.....	3
CHM 471 Solid-State Chemistry	3

Technical Electives

CHE 458 Semiconductor Material Processing	3
---	---

CHE 494 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.....	2

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

First Year

First Semester

CHM 113 General Chemistry <i>SQ</i>	4
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	14

Second Semester

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

Second Year

First Semester

CHE 311 Introduction to Chemical Processing	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
ECE core elective.....	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
MAT 274 Elementary Differential Equations <i>MA</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ² ..	3
Total	18

Second Semester

CHE 331 Transport Phenomena I: Fluids	3
ECE 350 Structure and Properties of Materials	3
ECE 384 Numerical Methods for Engineers.....	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
HU/SB and awareness area course.....	3
Total	17

Third Year

First Semester

CHE 334 Transport Phenomena II: Heat and Mass Transfer.....	4
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>L</i>	3
Total	15

Second Semester

CHE 352 Transport Laboratories.....	2
CHE 433 Modern Separations	3
CHE 442 Chemical Reactor Design	3
CHM 332 General Organic Chemistry	3
HU/SB and awareness area course.....	3
Technical elective.....	3
Total	17

Fourth Year

First Semester

CHE 432 Principles of Chemical Engineering Design.....	2
CHE 451 Chemical Engineering Laboratory.....	2
CHE 461 Process Control <i>CS</i>	4
HU/SB and awareness area course.....	3
Technical electives	6
Total	17

Second Semester

CHE 462 Process Design <i>L</i>	3
HU/SB and awareness area course.....	3
Technical electives	9
Total	15
Total degree requirements	128

¹ Both PHY 121 and 122 must be taken to secure *SQ* credit.

² Both PHY 131 and 132 must be taken to secure *SQ* credit.

**MATERIALS SCIENCE AND ENGINEERING—
B.S.E.**

Materials engineers create innovations that result in new and improved materials that help drive the cutting edge of new technologies in many industries. These include the auto, aerospace, electronics, semiconductor, materials production, and health professions. The space shuttle, light-weight cars, and today's fastest computers have all been developed using the latest materials technologies. In advancing today's technologies, materials engineers fulfill a wide range of job responsibilities that significantly impact other engineering disciplines and include

1. selecting the best material for a given application or developing innovative materials and processing techniques for new applications;
2. characterizing and analyzing failed products in order to redesign more reliable and robust engineering components; and
3. impacting technological advances in larger-scale projects through working in a team environment with other engineers from the chemical, electrical, mechanical, aerospace and other engineering disciplines.

The Materials Science and Engineering degree program at ASU has outstanding faculty who have national reputations in the areas of both structural and electronic materials. The faculty bring significant professional expertise to classroom teaching, which is complemented by enlightening experimental work in the program's contemporary, well-equipped laboratory facilities. This atmosphere promotes quality undergraduate research projects and senior design projects that frequently result in patents and technical publications. Examples of recent patent applications include an improved method for producing artificial Teflon arteries and an improved technique for testing steel in air bag containers. Such preparation and experiences give the program's

L literacy and critical inquiry / *MA* mathematics / *CS* computer/statistics/ quantitative applications / *HU* humanities and fine arts / *SB* social and behavioral sciences / *SG* natural science—general core courses / *SQ* natural science—quantitative / *C* cultural diversity in the United States / *G* global / *H* historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

graduates an edge in seeking employment at the best companies or admission to the nation's leading graduate schools. The program's educational experience is also enhanced by numerous scholarships available to students ranging from entering freshmen to final-year seniors.

The Materials Science and Engineering degree program is accredited by the national organization of Accreditation Board for Engineering and Technology, Inc. As such, it has an identifiable program mission, objectives, and outcomes, which reflect, encompass, and embody the unique educational development that a student experiences as he or she progresses through the program to graduation. The mission and objectives are described below.

The mission of the Materials Science and Engineering degree program is to provide a solid educational foundation in the application of the principles of science and engineering toward the design, utilization, and improvement of materials in engineering components and systems for the betterment of society. This mission, with the associated objectives and outcomes, also supports the mission and goals of ASU and the Ira A. Fulton School of Engineering. To accomplish this mission, the program's graduates fulfill the following objectives: (1) graduates will have the strong educational foundation in materials science and engineering that promotes success in the broad range of career opportunities available in graduate school, industry, and government; and (2) graduates will have the personal skills and values that promote their success in the rapidly changing, culturally diverse workplace that reflects the needs of contemporary society.

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. Students must attain a GPA of at least 2.00 for the courses in the major field.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 87.

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 study. 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	12
Total	15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L</i>	3
MSE 482 Materials Engineering Design <i>L</i>	3
Total	6

Natural Sciences/Basic Sciences

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

Mathematical Studies

ECE 100 Introduction to Engineering Design <i>CS</i>	3
MAT 242 Elementary Linear Algebra	2
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
Total	20
General Studies/school requirements total	57

Engineering Core

ECE 201 Electrical Networks I	4
ECE 210 Engineering Mechanics I: Statics	3
ECE 313 Introduction to Deformable Solids	3
ECE 350 Structure and Properties of Materials	3
MSE 430 Thermodynamics of Materials	3
Total	16

Major

Select two of the following five courses ³	6
CHM 302 Environmental Chemistry (3)	
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	12
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
MSE 111 Challenges in Materials Engineering	1
MSE 353 Introduction to Materials Processing and Synthesis	3
MSE 354 Experiments in Materials Synthesis and Processing	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 490 Capstone Design Project.....	3
Total	49

- ¹ Both PHY 121 and 122 must be taken to secure SQ credit.
- ² Both PHY 131 and 132 must be taken to secure SQ credit.
- ³ To take CHM 341 Elementary Physical Chemistry, CHM 331 Organic Chemistry must be taken as the prerequisite.

Materials Science and Engineering Areas of Study

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 L*.....	3
BME 416 Biomechanics	3

* Both BME 413 and 423 must be taken to secure L credit.

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

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	4
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

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
IEE 300 Economic Analysis for Engineers.....	3
IEE 360 Manufacturing Processes	3
or MAE 351 Manufacturing Processes (3)	
IEE 361 Manufacturing Processes Lab	1
IEE 368 Facilities Analysis and Design.....	3
IEE 369 Work Analysis and Design.....	3
IEE 431 Engineering Administration.....	3
IEE 437 Human Factors Engineering	3
IEE 461 Production Control.....	3
IEE 463 Computer-Aided Manufacturing Control CS.....	3
MAE 422 Mechanics of Materials.....	4
MAE 441 Principles of Design.....	3
MAE 442 Mechanical Systems Design	4
MSE 431 Corrosion and Corrosion Control.....	3
MSE 441 Analysis of Material Failures.....	3

Mechanical Metallurgy. Students interested in understanding the design, processing, and manufacturing of metals for structural applications, such as autos, airplanes, and buildings, 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	4
MSE 431 Corrosion and Corrosion Control.....	3
MSE 441 Analysis of Material 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

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

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

First Year

First Semester	
CHM 113 General Chemistry SQ	4
ECE 100 Introduction to Engineering Design CS.....	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I MA.....	4
MSE 111 Challenges in Materials Engineering	1
Total	15

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Second Semester

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

Second Year

First Semester

ECE 210 Engineering Mechanics I: Statics	3
ECE 350 Structure and Properties of Materials	3
MAT 242 Elementary Linear Algebra	2
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ²	3
PHY 132 University Physics Laboratory II <i>SQ</i> ²	1
Total	16

Second Semester

ECE 201 Electrical Networks I	4
ECE 313 Introduction to Deformable Solids	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
MAT 274 Elementary Differential Equations <i>MA</i>	3
Technical elective	3
Total	16

Third Year

First Semester

ECE 300 Intermediate Engineering Design <i>L</i>	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
MSE 353 Introduction to Materials Processing and Synthesis	3
MSE 355 Introduction to Materials Science and Engineering	3
Advanced science course ³	3
Total	15

Second Semester

MSE 354 Experiments in Materials Synthesis and Processing	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 ⁴	3
Advanced science course ³	3
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 <i>L</i>	3
Technical electives	3
HU/SB and awareness area course ⁴	3
Total	18

Second Semester

MSE 490 Capstone Design Project	3
HU/SB and awareness area course ⁴	6

Technical elective	6
Total	15
Total degree requirements	128

¹ Both PHY 121 and 122 must be taken to secure *SQ* credit.

² Both PHY 131 and 132 must be taken to secure *SQ* credit.

³ To take CHM 341 Elementary Physical Chemistry, CHM 331 General Organic Chemistry must be taken as the prerequisite.

⁴ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements.

GRADUATE STUDY

The faculty in the Department of Chemical and Materials Engineering also offer graduate programs leading to the M.S., M.S.E., and Ph.D. degrees. These programs provide a blend of classroom instruction and research. Many diverse 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 (CHE)

CHE 311 Introduction to Chemical Processing. (3)

fall

Applies 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)

spring

Transport phenomena, with emphasis on fluid systems. Prerequisites: CHE 311; MAT 274; PHY 131.

CHE 334 Transport Phenomena II: Heat and Mass Transfer. (4)

fall

Applies heat and mass transport principles. Design of heat exchangers and continuous contactors. Prerequisite: CHE 331.

CHE 342 Applied Chemical Thermodynamics. (4)

fall

Applies conservation and accounting principles with nonideal property estimation techniques to model phase and chemical equilibrium processes. Lecture, recitation. Prerequisite: CHE 311; ECE 350; PHY 131. Pre- or corequisite: MAT 272.

CHE 352 Transport Laboratories. (2)

spring

Demonstrates transport phenomena principles with experiments in fluid flow, heat, and mass transfer. Fee. Prerequisites: CHE 334; ECE 300.

CHE 432 Principles of Chemical Engineering Design. (2)

fall

Multicomponent distillation, engineering economics, equipment sizing and costs, plant operation economics, and simulation and optimization techniques. Fee. Prerequisites: CHE 334, 342.

CHE 433 Modern Separations. (3)

spring

Design of modern separation equipment in chemical engineering other than fractionation. Prerequisites: CHE 334, 342.

CHE 442 Chemical Reactor Design. (3)

spring

Applies kinetics to chemical reactor design. Prerequisites: CHE 334, 342.

CHE 451 Chemical Engineering Laboratory. (2)

fall

Operation, control, and design of experimental and industrial process equipment; independent research projects. 6 hours lab. Fee. Prerequisites: CHE 334, 352; ECE 384.

CHE 458 Semiconductor Material Processing. (3)

selected semesters

Introduces the processing and characterization of electronic materials for semiconductor applications. Prerequisites: CHE 334, 342.

CHE 461 Process Control. (4)

fall

Process dynamics, instrumentation, and feedback applied to automatic process control. Lecture, lab. Fee. Prerequisites: ECE 384; MAT 274.

General Studies: CS

CHE 462 Process Design. (3)

spring

Applies economic principles to optimize equipment selection and design; development and design of process systems. Prerequisites: CHE 432, 433, 442.

General Studies: L

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

fall

Conflict of processing materials and preserving the natural resources. Teaches students to understand and value the environment and attempt to control our impact. Prerequisites: CHE 334, 342.

CHE 475 Biochemical Engineering. (3)

selected semesters

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

CHE 476 Bioreaction Engineering. (3)

selected semesters

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)

selected semesters

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

CHE 478 Industrial Water Quality Engineering. (3)

fall

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

CHE 490 Chemical Engineering Projects. (1–5)

fall, spring, summer

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

CHE 492 Honors Directed Study. (1–6)

selected semesters

CHE 493 Honors Thesis. (1–6)

selected semesters

CHE 494 Special Topics. (1–4)

fall and spring

Topics may include the following:

- Advanced Process Control. (3)
- Biotechnology Techniques. (3)

CHE 496 Professional Seminar. (1–3)

fall and spring

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

CHE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

MATERIALS SCIENCE AND ENGINEERING (MSE)

MSE 111 Challenges in Materials Engineering. (1)

fall

Introduces current issues and concepts of materials engineering, relationship between materials properties, application to engineering problems. Pre- or corequisite: ECE 100.

MSE 353 Introduction to Materials Processing and Synthesis. (3)

fall

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 their equivalents).

MSE 354 Experiments in Materials Synthesis and Processing. (2)

spring

Small groups of students complete three experiments selected from a list. Each is supervised by a selected faculty member. Lab. Fee. Prerequisite: MSE 353 (or its equivalent).

MSE 355 Introduction to Materials Science and Engineering. (3)

fall

Elements of the structure of metals and alloys, measurement of mechanical properties, and optical metallography. Lecture, lab, field trips. Fee. Prerequisite: CHM 114 or 116.

MSE 394 Special Topics. (1–4)

selected semesters

Topics may include the following:

- Computer and Experimental Methods in Materials. (3)

MSE 420 Physical Metallurgy. (3)

spring

Crystal structure and defects. Phase diagrams, metallography, solidification and casting, deformation, and annealing. Prerequisite: ECE 350.

MSE 421 Physical Metallurgy Laboratory. (1)

spring

Focuses on analysis of microstructure of metals and alloys and includes correlation with mechanical properties to some extent. Lab. Fee. Pre- or corequisite: MSE 420.

MSE 430 Thermodynamics of Materials. (3)

spring

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)

spring in odd years

Introduces corrosion mechanisms and methods of preventing corrosion. Topics include: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: ECE 350.

MSE 440 Mechanical Properties of Solids. (3)

fall

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)

spring in even years

Identifies 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)

spring

Fundamentals of x-ray diffraction, transmission electron microscopy, and scanning electron microscopy. Techniques for studying surfaces, internal microstructures, and fluorescence. Lecture, demonstrations. Fee. Prerequisite: ECE 350.

MSE 470 Polymers and Composites. (3)

fall

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. Prerequisites: ECE 313, 350.

MSE 471 Introduction to Ceramics. (3)

fall

Principles of structure and property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: ECE 350.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

MSE 482 Materials Engineering Design. (3)

fall

Principles of the design process. Feasibility and optimization. Manufacturing processes, materials selection, failure analysis, and economics. Prerequisites: ECE 300; ENG 101 (or 105 or 107); MSE 354, 355. *General Studies: L*

MSE 490 Capstone Design Project. (1–3)

fall and spring

For small groups in fundamental or applied aspects of engineering materials; emphasizes experimental problems and design. Fee. Prerequisites: MSE 430, 440, 450.

MSE 492 Honors Directed Study. (1–6)

selected semesters

MSE 493 Honors Thesis. (1–6)

selected semesters

MSE 494 Special Topics. (1–4)

selected semesters

Topics may include the following:

- Composite Materials. (3)
- Electronic, Optical, and Magnetic Properties of Materials. (3)
- Engineering Disasters: Heavy Metal Toxicity
- Growth and Processing of Semiconductors. (3)
- Growth and Processing of Semiconductors Laboratory. (1)
- Nanomaterials: Synthesis and Evaluation. (3)
- Scanning Probe Microscopy. (3)
- Vacuum Systems Science and Engineering. (3)

MSE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Department of Civil and Environmental Engineering

www.fulton.asu.edu/~civil

480/965-3589

ECG 252

Sandra L. Houston, Chair

Richard Snell Presidential Chair Professor: Crittenden

Professors: Fox, S. Houston, Johnson, Mamlouk, Mays, Rajan, Singhal, Witczak

Associate Professors: Abbaszadegan, Fafitis, Hinks, Mobasher, Muccino, Westerhoff

Assistant Professors: Allen, Dillner, Kaloush, Owusu-Antwi, Peccia

Research Faculty: Alum, Esparza-Soto, Febres, Hokanson, Lee, Mash, Zapata

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 Department of Civil and Environmental Engineering offers 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, and 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 examination and professional registration.

The Department of Civil and Environmental Engineering at ASU strongly believes in the development of programmatic objectives and outcomes, and a continuous quality improvement program. The four preeminent learning objectives for the program deal with the ability of graduates to

1. be technically competent,
2. be effective members of society,
3. communicate effectively, and
4. analyze and design civil engineering systems with due considerations to cost, environmental and construction factors.

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/Geoenvironmental 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, response of foundations and embankments to earthquakes, and solutions to environmental problems.

Structures/Materials Engineering. This area of study considers the planning, analysis and design of steel and concrete bridges, buildings, dams; special offshore and space

structures; Portland cement concrete; composite materials; and structural retrofit of existing bridges.

Transportation/Materials Engineering. This area of study includes (1) transportation design and operation and (2) pavements and materials. Transportation design and operation cover geometric design of highways, traffic operations, and highway capacity and safety. Pavements and materials focus on pavement analysis and design, pavement maintenance and rehabilitation, pavement evaluation and management, characterization of highway materials, and durability of highway structures.

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.

UNDERGRADUATE OPPORTUNITIES IN CIVIL AND ENVIRONMENTAL ENGINEERING

Students majoring in Civil Engineering have three choices:

1. the major without a concentration;
2. the major with a concentration in construction engineering; and
3. the major with a concentration in environmental engineering.

Civil Engineering. The B.S.E. degree in Civil Engineering offers students a wide background on various areas of study within civil engineering. The degree provides basic principles of environmental, geotechnical/geoenvironmental, structural/materials, transportation/materials, and water resources engineering. Students have the option to select among a certain number of design and technical elective courses in their junior and senior years.

Civil Engineering with Construction Engineering Concentration. The B.S.E. degree in Civil Engineering with a construction engineering concentration offers students basic principles of civil engineering with the option to concentrate on construction engineering. The degree provides education based on the traditional engineering principles, construction materials and practice, quality control, and civil engineering project management.

Civil Engineering with Environmental Engineering Concentration. The B.S.E. degree in Civil Engineering with an environmental engineering concentration offers students basic principles of civil engineering with the option to concentrate on environmental engineering. The degree provides a multidisciplinary education based on the traditional engineering principles, chemistry, biology, and hydrogeology.

CIVIL ENGINEERING—B.S.E.

The B.S.E. degree in Civil Engineering requires 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,

and computer programming along with precalculus, algebra, and trigonometry.

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

First-Year Composition	6
General Studies/school requirements	55
Engineering core	18–19
Civil Engineering major	27
Design courses	6
Technical courses	15–16
Minimum requirement	128

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/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Macroeconomic Principles <i>SB</i> (3)	
HU course(s)	6–9
<i>SB</i> courses	3–6
Minimum total	15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L</i>	3
CEE 486 Integrated Civil Engineering Design <i>L</i>	3
Total	6

Natural Sciences/Basic Sciences

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

Mathematical Studies

MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
ECE 384 Numerical Methods for Engineers	4
Total	19
General Studies/school requirements total	55

Engineering Core

ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECE 201 Electrical Networks I	4
or ECE 340 Thermodynamics (3)	

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

ECE 210	Engineering Mechanics I: Statics.....	3
ECE 212	Engineering Mechanics II: Dynamics.....	3
ECE 313	Introduction to Deformable Solids.....	3
ECE 351	Civil Engineering Materials.....	3
Total	.....	18-19

¹ Both PHY 121 and 122 must be taken to secure SQ credit.

² Both PHY 131 and 132 must be taken to secure SQ credit.

Civil Engineering Major

CEE 296	Civil Engineering Systems.....	4
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 CS.....	3
Total	.....	27

Design Courses for the Degree Without a Concentration

Six semester hours from the following list are required.

CEE 420	Steel Structures.....	3
	or CEE 421 Concrete Structures (3)	
CEE 441	Water Resources Engineering.....	3
CEE 452	Foundations.....	3
CEE 466	Sanitary Systems Design.....	3
CEE 475	Highway Geometric Design.....	3

Technical Courses for the Degree Without a Concentration

From 15 to 16 semester hours are required. The design elective courses that have not been selected to satisfy the design electives requirement may be used as technical electives.

A maximum of four hours may be selected from outside civil engineering, with an advisor's approval. Construction courses taken as technical electives may be selected from the following list: CON 383, 495, and 496. Students must select technical and design electives from at least three different CEE areas of study.

Environmental Engineering

CEE 362	Unit Operations in Environmental Engineering.....	3
CEE 466	Sanitary Systems Design.....	3
CEE 467	Environmental Microbiology.....	4
CHM 231	Elementary Organic Chemistry SQ*.....	3

* Both CHM 231 and 235 must be taken to secure SQ credit.

Geotechnical/Geoenvironmental Engineering

CEE 452	Foundations.....	3
---------	------------------	---

Structures/Materials Engineering

CEE 420	Steel Structures.....	3
CEE 421	Concrete Structures.....	3
CEE 423	Structural Design.....	3
CEE 432	Developing Software for Engineering Applications.....	3

Transportation/Materials Engineering

CEE 381	Surveying.....	3
CEE 412	Pavement Analysis and Design.....	3
CEE 474	Transportation Systems Engineering.....	3
CEE 475	Highway Geometric Design.....	3

CEE 481	Civil Engineering Project Management.....	3
CEE 483	Highway Materials, Construction, and Quality.....	3

Water Resources Engineering

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

Design Courses for the Degree with the Construction Engineering Concentration

CEE 420	Steel Structures.....	3
CEE 452	Foundations.....	3
Total	.....	6

Technical Courses for the Degree with the Construction Engineering Concentration

CEE 381	Surveying.....	3
CEE 421	Concrete Structures.....	3
CEE 481	Civil Engineering Project Management.....	3
CEE 483	Highway Materials, Construction, and Quality.....	3
CON 496	Construction Contract Administration.....	3
Total	.....	15

Design Courses for the Degree with the Environmental Engineering Concentration

CEE 441	Water Resources Engineering.....	3
CEE 466	Sanitary Systems Design.....	3
Total	.....	6

Technical Courses for the Degree with the Environmental Engineering Concentration

BIO 320	Fundamentals of Ecology.....	3
	or BCH 361 Principles of Biochemistry (3)	
	or CHM 302 Environmental Chemistry (3)	
	or CHM 341 Elementary Physical Chemistry (3)	
	or PUP 442 Environmental Planning (3)	
	or PUP 475 Environmental Impact Assessment (3)	
CEE 362	Unit Operations in Environmental Engineering.....	3
CEE 440	Engineering Hydrology.....	3
CEE 467	Environmental Microbiology.....	4
Technical elective*	.....	3
Total	.....	16

* This course is selected from the list of technical courses for the degree without a concentration.

Civil Engineering Program of Study A Four-Year Sequence

First Year

First Semester

CHM 114	General Chemistry for Engineers SQ.....	4
	or CHM 116 General Chemistry SQ (4)	
ECE 100	Introduction to Engineering Design CS.....	3
ENG 101	First-Year Composition.....	3
MAT 270	Calculus with Analytic Geometry I MA.....	4
Total	.....	14

Second Semester

CEE 296	Civil Engineering Systems.....	4
ECN 111	Macroeconomic Principles SB.....	3
	or ECN 112 Microeconomic Principles SB (3)	
ENG 102	First-Year Composition.....	3
MAT 271	Calculus with Analytic Geometry II MA.....	4
PHY 121	University Physics I: Mechanics SQ ¹	3

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

PHY 122 University Physics Laboratory I <i>SQ</i> ¹	1
Total	18

Second Year

First Semester

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

Second Semester

ECE 201 Electrical Networks I.....	4
or ECE 340 Thermodynamics (3)	
ECE 212 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
Basic science elective.....	3
Total	15-16

Third Year

First Semester

CEE 321 Structural Analysis and Design.....	4
CEE 372 Transportation Engineering.....	4
ECE 300 Intermediate Engineering Design <i>L</i>	3
ECE 351 Civil Engineering Materials.....	3
ECE 384 Numerical Methods for Engineers.....	4
Total	18

Second Semester

CEE 341 Fluid Mechanics for Civil Engineers.....	4
CEE 351 Geotechnical Engineering.....	4
CEE 361 Introduction to Environmental Engineering.....	4
HU/SB and awareness area course ³	3
Total	15

Fourth Year

First Semester

Design elective.....	3
HU/SB and awareness area course ³	3
Technical electives.....	9
Total	15

Second Semester

CEE 486 Integrated Civil Engineering Design <i>L</i>	3
Design elective.....	3
HU/SB and awareness area course ³	3
Technical electives.....	6-7
Total	15-16
Minimum total	128

¹ Both PHY 121 and 122 must be taken to secure SQ credit.
² Both PHY 131 and 132 must be taken to secure SQ credit.
³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Students should consider the following list of electives to enhance communication and management skills: COM 100, 110, 320; CON 101; PUP 100, 200.

Construction Engineering Concentration
 Program of Study
 A Four-Year Sequence

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>SQ</i>	4
or CHM 116 General Chemistry <i>SQ</i> (4)	
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	14

Second Semester

CEE 296 Civil Engineering Systems.....	4
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>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ¹	3
PHY 122 University Physics Laboratory I <i>SQ</i> ¹	1
Total	18

Second Year

First Semester

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

Second Semester

ECE 201 Electrical Networks I.....	4
ECE 212 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
Basic science elective.....	3
Total	16

Third Year

First Semester

CEE 321 Structural Analysis and Design.....	4
CEE 372 Transportation Engineering.....	4
ECE 300 Intermediate Engineering Design <i>L</i>	3
ECE 351 Civil Engineering Materials.....	3
ECE 384 Numerical Methods for Engineers.....	4
Total	18

Second Semester

CEE 341 Fluid Mechanics for Civil Engineers.....	4
CEE 351 Geotechnical Engineering.....	4
CEE 361 Introduction to Environmental Engineering.....	4
HU/SB and awareness area course ³	3
Total	15

Fourth Year

First Semester

CEE 381 Surveying.....	3
------------------------	---

L literacy and critical inquiry / *MA* mathematics / *CS* computer/statistics/quantitative applications / *HU* humanities and fine arts / *SB* social and behavioral sciences / *SG* natural science—general core courses / *SQ* natural science—quantitative / *C* cultural diversity in the United States / *G* global / *H* historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

CEE 420 Steel Structures	3
CEE 452 Foundations	3
CEE 481 Civil Engineering Project Management	3
HU/SB and awareness area course ³	3
Total	15

Second Semester

CEE 421 Concrete Structures	3
CEE 483 Highway Materials, Construction, and Quality	3
CEE 486 Integrated Civil Engineering Design <i>L</i>	3
CON 496 Construction Contract Administration	3
HU/SB and awareness area course ³	3
Total	15
Graduation requirement total	128

¹ Both PHY 121 and 122 must be taken to secure SQ credit.

² Both PHY 131 and 132 must be taken to secure SQ credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Students should consider the following list of electives to enhance communication and management skills: COM 100, 110, 320; CON 101; PUP 100, 200.

Environmental Engineering Concentration Program of Study A Four-Year Sequence

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>SQ</i>	4
or CHM 116 General Chemistry <i>SQ</i> (4)	
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	14

Second Semester

CEE 296 Civil Engineering Systems	4
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>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ¹	3
PHY 122 University Physics Laboratory I <i>SQ</i> ¹	1
Total	18

Second Year

First Semester

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

Second Semester

CHM 231 Elementary Organic Chemistry <i>SQ</i> ⁴	3
ECE 212 Engineering Mechanics II: Dynamics	3
ECE 313 Introduction to Deformable Solids	3
ECE 340 Thermodynamics	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
Total	15

Third Year

First Semester

CEE 321 Structural Analysis and Design	4
CEE 372 Transportation Engineering	4
ECE 300 Intermediate Engineering Design <i>L</i>	3
ECE 351 Civil Engineering Materials	3
ECE 384 Numerical Methods for Engineers	4
Total	18

Second Semester

CEE 341 Fluid Mechanics for Civil Engineers	4
CEE 351 Geotechnical Engineering	4
CEE 361 Introduction to Environmental Engineering	4
HU/SB and awareness area course ³	3
Total	15

Fourth Year

First Semester

CEE 362 Unit Operations in Environmental Engineering	3
CEE 440 Engineering Hydrology	3
CEE 466 Sanitary Systems Design	3
CEE 467 Environmental Microbiology	4
HU/SB and awareness area course ³	3
Total	16

Second Semester

BIO 320 Fundamentals of Ecology	3
or BCH 361 Principles of Biochemistry (3)	
or CHM 302 Environmental Chemistry (3)	
or CHM 341 Elementary Physical Chemistry (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>L</i>	3
HU/SB and awareness area course ³	3
Technical elective ⁵	3
Total	15
Graduation requirement total	128

¹ Both PHY 121 and 122 must be taken to secure SQ credit.

² Both PHY 131 and 132 must be taken to secure SQ credit.

³ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Students should consider the following list of electives to enhance communication and management skills: COM 100, 110, 320; CON 101; PUP 100, 200.

⁴ Both CHM 231 and 235 must be taken to secure SQ credit.

⁵ This course is selected from the list of technical courses for the degree without a concentration.

GRADUATION REQUIREMENTS

Each sequence of mathematics, engineering core, civil engineering major, and the combined design and technical courses must be completed with an average grade of "C" (2.00) or higher. CEE courses, except CEE 296, may not be taken before the engineering core courses are completed. Design and technical courses may not be taken before the civil engineering major courses are completed. CEE 486 is taken in the last semester of course work.

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

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See “University Graduation Requirements,” page 87.

Concurrent Studies in Architecture and Civil Engineering

Qualified lower-division students interested in combining undergraduate studies in architecture and civil engineering may prepare for upper-division and graduate courses in both programs by taking courses to meet requirements for option B under the Architectural Studies major. See “Architectural Studies—B.S.D. Lower-Division Requirements Option A¹,” page 139.

GRADUATE STUDY

The Department of Civil and Environmental Engineering also offers graduate programs leading to the M.S., M.S.E., and Ph.D. degrees. These programs provide a blend of classroom instruction and research. Many topics and relevant research projects are available for thesis programs. Students interested in these programs should review the *Graduate Catalog* for up-to-date literature.

CIVIL AND ENVIRONMENTAL ENGINEERING (CEE)

CEE 296 Civil Engineering Systems. (4)

fall and spring

Introduces civil engineering. Problem solving, economics, description of civil engineering systems, design concepts, ethics, professional responsibilities, and computer graphics. Lecture, computer labs, field trips. Fee. Pre- or corequisite: ECE 100.

CEE 321 Structural Analysis and Design. (4)

fall and spring

Statically determinate and indeterminate structures (trusses, beams, and frames) by classical and matrix methods. Introduces structural design. Lecture, recitation. Prerequisites: ECE 212, 313. Pre- or corequisites: ECE 380, 384.

CEE 340 Hydraulics and Hydrology. (3)

fall and spring

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

CEE 341 Fluid Mechanics for Civil Engineers. (4)

fall and spring

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. Fee. Prerequisites: ECE 212, 313. Pre- or corequisites: ECE 380, 384.

CEE 351 Geotechnical Engineering. (4)

fall and spring

Index properties and engineering characteristics of soils. Compaction, permeability and seepage, compressibility and settlement, and shear strength. Lecture, lab. Fee. Prerequisites: ECE 212, 313. Pre- or corequisites: ECE 380, 384.

CEE 361 Introduction to Environmental Engineering. (4)

fall and spring

Concepts of air and water pollution; environmental regulation, risk assessment, chemistry, water quality modeling, water and wastewater treatment systems designs. Lecture, lab. Fee. Prerequisites: ECE 212, 313. Pre- or corequisites: ECE 380, 384.

CEE 362 Unit Operations in Environmental Engineering. (3)

spring

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

CEE 372 Transportation Engineering. (4)

fall and spring

Highway, rail, water, and air transportation. Operational characteristics and traffic control devices of each transport mode. Impact on urban

form. Prerequisites: ECE 212, 313. Pre- or corequisites: ECE 380, 384.

CEE 381 Surveying. (3)

fall, spring, summer

Theory and field work in construction and land surveys. Lecture, lab. Cross-listed as CON 341. Credit is allowed for only CEE 381 or CON 341. Fee. Prerequisite: MAT 270.

CEE 412 Pavement Analysis and Design. (3)

fall

Design of flexible and rigid pavements for highways and airports. Surface, base, and subgrade courses. Cost analysis and pavement selection. Credit is allowed for only CEE 412 or 511. Prerequisites: CEE 351; ECE 351.

CEE 420 Steel Structures. (3)

fall

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

CEE 421 Concrete Structures. (3)

spring

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

CEE 423 Structural Design. (3)

fall

Analysis and design of reinforced concrete steel, masonry, and timber structures. Fee. Prerequisite: CEE 421. Pre- or corequisite: CEE 420.

CEE 432 Developing Software for Engineering Applications. (3)

spring

Matrix and computer applications to structural engineering and structural mechanics. Stiffness and flexibility methods, finite elements, and differences. Credit is allowed for only CEE 432 or 532. Prerequisite: CEE 321.

CEE 440 Engineering Hydrology. (3)

fall

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)

spring

Applies 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 452 Foundations. (3)

fall

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

CEE 466 Sanitary Systems Design. (3)

fall

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

CEE 467 Environmental Microbiology. (4)

fall

Overview of the microbiology of natural and human-impacted environment, microbial detection methodologies, waterborne disease outbreaks, risk assessment, and regulations. Credit is allowed for only CEE 467 or 567. Lecture, lab. Fee. Prerequisite: CEE 361 or MIC 220.

CEE 474 Transportation Systems Engineering. (3)

fall

Introduces transportation systems and modeling, traffic characteristic analysis, traffic predictions, highway capacity, signal timing, transportation systems management, and transit. Prerequisites: CEE 372; ECE 384.

CEE 475 Highway Geometric Design. (3)

spring

Design of the visible elements of the roadway. Fundamental design controls with application to rural roads, at-grade intersections, free-

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

ways, and interchanges. Lecture, computer lab. Fee. Prerequisite: CEE 372.

CEE 481 Civil Engineering Project Management. (3) *once a year*

Civil engineering project management and administration, planning and scheduling, cost estimating and bidding strategies, financial management, quality control and safety, and computer applications. Lecture, field trips. Prerequisites: CEE 321, 351, 372.

CEE 483 Highway Materials, Construction, and Quality. (3) *once a year*

Properties of highway materials, including aggregates, asphalt concrete, and portland cement concrete; construction practice; material delivery, placement, and compaction; quality control. Lecture, field trips. Prerequisites: CEE 351, 372; ECE 351.

CEE 486 Integrated Civil Engineering Design. (3) *fall and spring*

Requires completion of a civil engineering design in a simulated practicing engineering environment. Limited to undergraduates in their final semester. Lecture, team learning. Prerequisites: CEE 321, 341, 351, 361, 372.

General Studies: L

CEE 492 Honors Directed Study. (1–6) *selected semesters*

CEE 493 Honors Thesis. (1–6) *selected semesters*

CEE 499 Individualized Instruction. (1–3) *selected semesters*

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Department of Computer Science and Engineering

cse.asu.edu

480/965-3190

BYENG

Sethuraman Panchanathan, Chair

Professors: Baral, Colbourn, Collofello, Farin, Golshani, Kambhampati, Lee, Lewis, Nielson, Panchanathan, Tsai, J. Urban, S. Urban, Yau

Associate Professors: Bazzi, Bhattacharya, Candan, Dasgupta, Dietrich, Faltz, Gupta, Huey, Liu, Miller, O'Grady, Sen, Xue

Assistant Professors: Cam, Chatha, Davulcu, Gannod, Konjevod, Richa, Ryu, Sarjoughian, Sundaram, Syrotiuk

Senior Lecturer: DeLibero

Lecturers: Boyd, Chen, Nakamura, Navabi, Turban

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. The following are shared objectives of the degree programs:

1. Graduates will understand current trends in information technology and be able to apply their understanding in the distributed management of information.
2. Graduates can apply the underlying principles of computer science, including mathematical and physical sciences and engineering principles.
3. Graduates will know and be able to apply system development processes, using modern tools, from the component level to the system level.
4. Graduates also will have the skills required to communicate effectively in both technical and nontechnical settings, to work effectively in teams and in a multicultural environment, to work ethically and professionally, and continue to learn independently and grow intellectually.

The Computer Systems Engineering program has the specific objective that its graduates will have the technical expertise necessary to analyze requirements and to design and implement effective solutions to problems that require the integration of hardware and software. The Computer Science program has the specific objective that its graduates will have the technical expertise necessary to analyze requirements and to design and implement effective solutions using computer science for a broad range of problems. The department strives to maintain a modern learning environment that fosters excellence, cooperation, and scholarship for faculty, students, and staff.

ADMISSION REQUIREMENTS

The Preprofessional Program. Each student admitted to the Department of Computer Science and Engineering is designated a preprofessional student in either Computer Science or Computer Systems Engineering. The student follows the first- and second-year sequence of courses listed in the curriculum outline for his or her particular major. Included in the first- and second-year schedules are all emphasis courses:

CSE 120	Digital Design Fundamentals.....	3
CSE 200	Concepts of Computer Science CS	3
CSE 210	Object-Oriented Design and Data Structures CS	3

CSE 225	Assembly Language Programming and Microprocessors (Motorola).....	4
	or CSE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
CSE 240	Introduction to Programming Languages	3
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)	
HU/SB elective chosen with an advisor (3)		
— or —		
ENG 107	English for Foreign Students (3)	
ENG 108	English for Foreign Students (3)	
MAT 243	Discrete Mathematical Structures	3
MAT 270	Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271	Calculus with Analytic Geometry II <i>MA</i>	4
MAT 272	Calculus with Analytic Geometry III <i>MA</i>	4
PHY 121	University Physics I: Mechanics <i>SQ</i> ¹	3
PHY 122	University Physics Laboratory I <i>SQ</i> ¹	1
PHY 131	University Physics II: Electricity and Magnetism <i>SQ</i> ² ..	3
PHY 132	University Physics Laboratory II <i>SQ</i> ²	1

¹ Both PHY 121 and 122 must be taken to secure SQ credit.

² Both PHY 131 and 132 must be taken to secure SQ credit.

The Professional Program. Admission to the professional program is competitive and granted to those applicants demonstrating the highest promise for professional success in Computer Science and Engineering. The admissions committee considers overall transfer and ASU GPA numbers as well as the transfer and ASU GPA numbers in Computer Science and Engineering emphasis courses. All students seeking professional status must have completed or be in the process of completing all the emphasis courses and then follow the application procedure as described on the Computer Science and Engineering Web site. Completion of the specified courses does not guarantee admission to professional status. Only students who have been admitted to ASU are eligible to apply for the professional programs. Candidates are strongly encouraged to visit the Computer Science and Engineering Advising Center in BYENG before beginning the application process. All application materials can be found on the Web at cse.asu.edu.

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 and a major GPA of 2.00 or higher, all computer science and computer systems engineering students must obtain a minimum grade of “C” (2.00) in all CSE courses used for degree credit. Students cannot take CSE courses for which they failed to earn a grade of “C” (2.00) or better in the prerequisite course.

The department calculates the major GPA in both Computer Science and Computer Systems Engineering based on an average of all CSE courses and technical electives which count toward the degree.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See “University Graduation Requirements,” page 87.

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, visit the department, call 480/965-3190, or access the department’s Web site at cse.asu.edu.

Software Engineering Concentration. Students pursuing the B.S. degree in Computer Science may choose to concentrate their studies on software engineering. The B.S. Degree in Computer Science with a concentration in software engineering provides recognition that the student has acquired in-depth knowledge and hands-on experience in software development and related subjects. This concentration requires the student to complete CSE 445, 460, 461, and 462 with a grade of “C” (2.00) or higher in each.

The following table 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)	
— or —	
ENG 105 Advanced First-Year Composition (3)	
HU/SB 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/Department Requirements

<i>Humanities and Fine Arts/Social and Behavioral Sciences</i>	
HU/SB electives.....	18
<i>Literacy and Critical Inquiry</i>	
L elective.....	3
ECE 400 Engineering Communications.....	3
or approved CSE L course (3)	
Total	6
<i>Natural Sciences/Basic Sciences</i>	
PHY 121 University Physics I: Mechanics <i>SQ</i> ¹	3
PHY 122 University Physics Laboratory I <i>SQ</i> ¹	1
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ²	3
PHY 132 University Physics Laboratory II <i>SQ</i> ²	1

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Science elective ³	4
Total	12
<i>Mathematical Studies</i>	
ECE 380 Probability and Statistics for Engineering Problem Solving CS	3
MAT 243 Discrete Mathematical Structures	3
MAT 270 Calculus with Analytic Geometry I MA	4
MAT 271 Calculus with Analytic Geometry II MA	4
MAT 272 Calculus with Analytic Geometry III MA	4
MAT 342 Linear Algebra	3
or MAT 343 Applied 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 CS	3
CSE 210 Object-Oriented Design and Data Structures CS	3
CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
or CSE 226 Assembly Language Programming and Microprocessors (Intel) (4)	—
CSE 240 Introduction to Programming Languages	3
CSE 310 Data Structures and Algorithms	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 ⁴	18
Technical electives ⁵	6
Unrestricted electives	7
Total	31
Total degree requirements	128

¹ Both PHY 121 and 122 must be taken to secure SQ credit.

² Both PHY 131 and 132 must be taken to secure SQ credit.

³ Each student must complete a four-credit laboratory science course that meets major requirements in the discipline of the course selected and satisfies the SQ portion of the General Studies requirement. See an advisor for the approved listing.

⁴ Students cannot count toward graduation more than six semester hours of independent study courses including but not limited to CSE 484, 492, 493, and 499. Computer Science honors students are allowed to use an extra three semester hours for the L elective. The only course that meets the L elective requirement in this group is CSE 493.

⁵ Each student must complete six hours of courses chosen from the computer science technical elective list and approved by the student's advisor. See an advisor for the approved listing.

Computer Science Program of Study Typical Four-Year Sequence

First Year

First Semester

CSE 200 Concepts of Computer Science CS	3
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I MA	4
HU/SB and awareness area course ¹	3
Unrestricted elective	3
Total	16

Second Semester

CSE 120 Digital Design Fundamentals.....	3
CSE 210 Object-Oriented Design and Data Structures CS	3
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II MA	4
Unrestricted elective	3
Total	16

Second Year

First Semester

CSE 240 Introduction to Programming Languages	3
MAT 243 Discrete Mathematical Structures.....	3
MAT 272 Calculus with Analytic Geometry III MA	4
PHY 121 University Physics I: Mechanics SQ ²	3
PHY 122 University Physics Laboratory I SQ ²	1
HU/SB and awareness area course ¹	3
Total	17

Second Semester

CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
or CSE 226 Assembly Language Programming and Microprocessors (Intel) (4)	—
MAT 342 Linear Algebra	3
or MAT 343 Applied Linear Algebra (3)	—
PHY 131 University Physics II: Electricity and Magnetism SQ ³	3
PHY 132 University Physics Laboratory II SQ ³	1
HU/SB and awareness area course ¹	3
L elective.....	3
Total	17

Third Year

First Semester

CSE 310 Data Structures and Algorithms	3
CSE 330 Computer Organization and Architecture	3
CSE 360 Introduction to Software Engineering.....	3
HU/SB and awareness area course ¹	3
Laboratory Science SQ ⁴	4
Total	16

Second Semester

CSE 340 Principles of Programming Languages	3
CSE 355 Introduction to Theoretical Computer Science	3
ECE 380 Probability and Statistics for Engineering Problem Solving CS	3
HU/SB and awareness area course ¹	3
Technical elective.....	3
Total	15

Fourth Year

First Semester

CSE 430 Operating Systems	3
ECE 400 Engineering Communications.....	3
or approved CSE L course (3)	—
400-level CSE computer science breadth electives.....	9
Unrestricted elective	1
Total	16

Second Semester

400-level CSE computer science breadth electives.....	9
HU/SB and awareness area course ¹	3

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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 SQ credit.
- ³ Both PHY 131 and 132 must be taken to secure SQ credit.
- ⁴ Each student must complete a four-credit laboratory science course that meets major requirements in the discipline of the course selected and satisfies the SQ portion of the General Studies requirement. See an advisor for the approved listing.

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. Qualified students in this program may apply to participate in an industrial internship program offered through the Embedded Systems and Internetworking Consortium. Students who participate in this internship program receive academic credit (CSE 484) that applies to the technical elective requirement of the B.S.E. degree in Computer Systems Engineering. The following table 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)	
HU/SB 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/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 and SB electives	12
Total	15

Literacy and Critical Inquiry

CSE 423 Microcomputer System Hardware <i>L</i>	3
or CSE 438 Systems Programming <i>L</i> (3)	
ECE 300 Intermediate Engineering Design <i>L</i>	3
Total	6

Natural Sciences/Basic Sciences

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

Mathematical Studies

MAT 243 Discrete Mathematical Structures	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
or MAT 275 Modern Differential Equations <i>MA</i> (3)	
MAT 342 Linear Algebra	3
or MAT 343 Applied Linear Algebra (3)	
Total	21
General Studies/department requirement total.....	57

Engineering Core

CSE 200 Concepts of Computer Science <i>CS</i>	3
CSE 225 Assembly Language Programming and Microprocessors (Motorola)	4
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECE 201 Electrical Networks I	4
ECE 210 Engineering Mechanics I: Statics.....	3
ECE 334 Electronic Circuits	4
Total	21

Computer Science Core

CSE 120 Digital Design Fundamentals.....	3
CSE 210 Object-Oriented Design and Data Structures <i>CS</i>	3
CSE 240 Introduction to Programming Languages	3
CSE 310 Data Structures and Algorithms	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
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
Technical electives ³	6
Total	44
Degree requirement total.....	128

- ¹ Both PHY 121 and 122 must be taken to secure SQ credit.
- ² Both PHY 131 and 132 must be taken to secure SQ credit.
- ³ Each student must complete six hours of courses chosen from the computer science technical elective list and approved by the student's advisor. See an advisor for the approved listing.

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

First Year

First Semester

CSE 200 Concepts of Computer Science <i>CS</i>	3
ECE 100 Introduction to Engineering Design <i>CS</i>	3
or CSE 120 Digital Design Fundamentals (3)	
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	16

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Second Semester

CHM 114 General Chemistry for Engineers <i>SQ</i>	4
CSE 120 Digital Design Fundamentals.....	3
or ECE 100 Introduction to Engineering Design <i>CS</i> (3)	
CSE 210 Object-Oriented Design and Data Structures <i>CS</i>	3
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
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>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ¹	3
PHY 122 University Physics Laboratory I <i>SQ</i> ¹	1
Total	15

Second Semester

CSE 240 Introduction to Programming Languages	3
ECE 210 Engineering Mechanics I: Statics.....	3
MAT 274 Elementary Differential Equations <i>MA</i>	3
or MAT 275 Modern Differential Equations <i>MA</i> (3)	
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ²	3
PHY 132 University Physics Laboratory II <i>SQ</i> ²	1
HU/SB and awareness area course ³	3
Total	16

Third Year

First Semester

CSE 310 Data Structures and Algorithms	3
CSE 330 Computer Organization and Architecture	3
CSE 360 Introduction to Software Engineering.....	3
ECE 300 Intermediate Engineering Design <i>L</i>	3
MAT 342 Linear Algebra	3
or MAT 343 Applied Linear Algebra (3)	
Total	15

Second Semester

CSE 340 Principles of Programming Languages	3
CSE 355 Introduction to Theoretical Computer Science	3
CSE 421 Microprocessor System Design I.....	4
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
HU/SB and awareness area course ³	3
Total	16

Fourth Year

First Semester

CSE 422 Microprocessor System Design II.....	4
CSE 430 Operating Systems	3
ECE 201 Electrical Networks I	4
PHY 361 Introductory Modern Physics.....	3
HU/SB and awareness area course ³	3
Total	17

Second Semester

CSE 423 Microcomputer System Hardware <i>L</i>	3
or CSE 438 Systems Programming <i>L</i> (3)	
ECE 334 Electronic Circuits	4
HU/SB and awareness area course ³	3

Technical electives	6
Total	16

- Both PHY 121 and 122 must be taken to secure *SQ* credit.
- Both PHY 131 and 132 must be taken to secure *SQ* credit.
- 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 with C++. (3)

fall and spring
Principles of problem solving using C++, algorithm design, structured programming, fundamental algorithms and techniques, and computer systems concepts. Social and ethical responsibility. Lecture, lab. Prerequisite: MAT 170.
General Studies: CS

CSE 110 Principles of Programming with Java. (3)

fall and spring
Concepts of problem solving using Java, algorithm design, structured programming, fundamental algorithms and techniques, and computer systems concepts. Social and ethical responsibility. Lecture, lab. Prerequisite: MAT 170.
General Studies: CS

CSE 120 Digital Design Fundamentals. (3)

fall and spring
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. Fee. Prerequisite: computer literacy.

CSE 180 Computer Literacy. (3)

fall and spring
Introduces 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: CS

CSE 181 Applied Problem Solving with Visual BASIC. (3)

fall and spring
Introduces systematic definition of problems, solution formulation, and method validation. Requires computer solution using Visual BASIC for projects. Lecture, lab. Prerequisites: MAT 117; nonmajor.
General Studies: CS

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

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

CSE 200 Concepts of Computer Science. (3)

fall and spring
Overview of algorithms, languages, computing systems, theory. Problem solving by programming with a high-level language (Java or other). Lecture, lab. Fee. Prerequisite: CSE 100 or 110 or 1 year of high school programming with Java or C++ or PASCAL.
General Studies: CS

CSE 210 Object-Oriented Design and Data Structures. (3)

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

CSE 225 Assembly Language Programming and Microprocessors (Motorola). (4)

fall and spring
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. Fee. Prerequisites: CSE 100 (or 110 or 200); CSE 120 or EEE 120.

CSE 226 Assembly Language Programming and Microprocessors (Intel). (4)
fall and spring
 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. Fee. Prerequisites: CSE 100 (or 110 or 200); CSE 120 or EEE 120.

CSE 240 Introduction to Programming Languages. (3)
fall and spring
 Introduces the procedural (C/C++), applicative (LISP/Scheme), and declarative (Prolog) languages. Lecture, lab. Prerequisite: CSE 210.

CSE 310 Data Structures and Algorithms. (3)
fall and spring
 Advanced data structures and algorithms, including stacks, queues, trees (B, B+, AVL), and graphs. Searching for graphs, hashing, external sorting. Lecture, lab. Fee. Prerequisites: CSE 210; MAT 243.

CSE 330 Computer Organization and Architecture. (3)
fall and spring
 Instruction set architecture, processor performance and design; datapath, control (hardwired, microprogrammed), pipelining, input/output. Memory organization with cache, virtual memory. Prerequisite: CSE 225 (or 226) or EEE 225 (or 226).

CSE 340 Principles of Programming Languages. (3)
fall and spring
 Formal syntactic and semantic descriptions, compilation and implementation issues, and theoretical foundations for several programming paradigms. Prerequisites: either CSE 225 (or 226) or EEE 225 (or 226) and both CSE 240 and 310.

CSE 355 Introduction to Theoretical Computer Science. (3)
fall and spring
 Introduces formal language theory and automata, Turing machines, decidability/undecidability, recursive function theory, and complexity theory. Prerequisite: CSE 310.

CSE 360 Introduction to Software Engineering. (3)
fall and spring
 Software life cycle models; project management, team development environments and methodologies; software architectures; quality assurance and standards; legal, ethical issues. Fee. Prerequisites: CSE 210, 240.

CSE 408 Multimedia Information Systems. (3)
fall
 Design, use, and applications of multimedia systems. Introduces 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)
fall and spring
 Introduces DBMS concepts. Data models and languages. Relational database theory. Database security/integrity and concurrency. Fee. Prerequisite: CSE 310.

CSE 420 Computer Architecture I. (3)
once a year
 Computer architecture. Performance versus cost tradeoffs. Instruction set design. Basic processor implementation and pipelining. Prerequisite: CSE 330.

CSE 421 Microprocessor System Design I. (4)
fall and spring
 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. Fee. Prerequisite: CSE 225 or EEE 225.

CSE 422 Microprocessor System Design II. (4)
fall and spring
 Design of microcomputer systems using contemporary logic and microcomputer system components. Requires assembly language programming. Fee. Prerequisite: CSE 421.

CSE 423 Microcomputer System Hardware. (3)
fall and spring
 Information and techniques presented in CSE 422 are used to develop the hardware design of a multiprocessor, multiprogramming, microprocessor-based system. Fee. Prerequisite: CSE 422.
General Studies: L

CSE 428 Computer-Aided Processes. (3)
selected semesters
 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)
fall and spring
 Operating system structure and services, processor scheduling, concurrent processes, synchronization techniques, memory management, virtual memory, input/output, storage management, and file systems. Fee. Prerequisites: CSE 330, 340.

CSE 432 Operating System Internals. (3)
fall
 IPC, exception and interrupt processing, memory and thread management, user-level device drivers, and OS servers in a modern microkernel-based OS. Prerequisite: CSE 430.

CSE 434 Computer Networks. (3)
fall and spring
 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)
selected semesters
 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: L

CSE 440 Compiler Construction I. (3)
once a year
 Introduces 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)
fall and spring
 Frameworks for distributed software components. Foundations of client-server computing and architectures for distributed object systems. Dynamic discovery and invocation. Lecture, projects. Fee. Prerequisite: CSE 360 or instructor approval.

CSE 446 Client-Server User Interfaces. (3)
selected semesters
 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. Fee. Prerequisite: CSE 310 or instructor approval.

CSE 450 Design and Analysis of Algorithms. (3)
fall and spring
 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)
once a year
 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. (3)
selected semesters
 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.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

CSE 460 Software Analysis and Design. (3)

fall and spring

Object-oriented and structured analysis and design; software architecture and design patterns; component-based development; software safety and reliability. Fee. Prerequisite: CSE 360.

CSE 461 Software Engineering Project I. (3)

fall and spring

First of two-course software team-development sequence. Planning, management, design, and implementation using object-oriented technology, CASE tools, CMM-level-5 guidelines. Lecture, lab, oral and written communications. Fee. Prerequisite: CSE 360.

CSE 462 Software Engineering Project II. (3)

fall and spring

Second of two-course software team-development sequence. Software evolution, maintenance, reengineering, reverse engineering, component-based development, and outsourcing. Lecture, lab, oral and written communications. Fee. Prerequisite: CSE 461.

CSE 463 Introduction to Human Computer Interaction. (3)

spring

Design, evaluate, and implement interactive software intended for human use. Prerequisite: CSE 310.

CSE 470 Computer Graphics. (3)

fall and spring

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

CSE 471 Introduction to Artificial Intelligence. (3)

fall and spring

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

CSE 476 Introduction to Natural Language Processing. (3)

selected semesters

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)

once a year

Introduces parametric curves and surfaces, Bezier and B-spline interpolation, and approximation techniques. Prerequisites: CSE 210, 470; MAT 342.

CSE 484 Internship. (1–12)

selected semesters

CSE 492 Honors Directed Study. (1–6)

selected semesters

CSE 493 Honors Thesis. (1–6)

selected semesters

CSE 494 Special Topics. (1–4)

selected semesters

Topics may include the following:

- Computational Models for the Arts. (3)

fall

Covers computability and intractability; kolmogorov complexity in the context of randomness and determinism.

- Signal Processing and Programming for the Arts. (3)

spring

Introduces basic concepts behind the functioning of existing, widely used digital arts and media tools.

CSE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Department of Electrical Engineering

www.fulton.asu.edu/ee

480/965-3424

ENGRC 552

Stephen M. Goodnick, Chair

Regents' Professors: Balanis, Ferry, Heydt

Professors: Backus, Crouch, Goodnick, Gorur, Hoppensteadt, Hui, Karady, Kiaei, Kozicki, Lai, Palais, Pan, Phillips, Roedel, Schroder, Shen, Si, Spanias, Tao, Thornton, Y. Zhang

Associate Professors: Aberle, Allee, Bird, Chakrabarti, Cochran, Diaz, El-Sharawy, Grondin, Holbert, Karam, Kim, Morrell, Rodriguez, Skromme, Tsakalis, Tylavsky

Assistant Professors: Ayyanar, Duman, Joo, Papandreou-Suppappola, Qian, Reisslein, Tepedelenioglu, Vasileska, J. Zhang

The professional activities of electrical engineers directly affect the everyday lives of most of the world's population. 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. These engineers design systems for automatically controlling mechanical devices and a variety of processes. These engineers 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.

This goal is achieved through a curriculum designed to accomplish five objectives:

1. We will maintain a modern curriculum, which adapts to changes in technology and society.
2. Our program will foster a diverse student population entering and successfully graduating, and our graduates will function well in a diverse work force.
3. Our graduates will be self-motivated, creative people who can succeed in environments where technical innovation is important.
4. Our graduates will be sought after by our constituent industries and respected graduate programs.
5. Our graduates will be technically competent.

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 four backbone courses employing engineering teams: ECE 100 Introduction to Engineering Design (freshman year), ECE 300 Intermediate Engineering Design (junior year), EEE 488 Senior Design Laboratory I, and EEE 489 Senior Design Laboratory II. The integrated experience is strengthened with required courses: EEE 120 Digital Design Fundamentals, EEE 225 Assembly Language Programming and Microprocessors (Motorola), EEE 226 Assembly Language Programming and Microprocessors (Intel), 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 488 and EEE 489.

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” (2.00) or higher in the mathematics and physics courses listed in the program of study. Each mathematics and physics course in the program of study must be completed with a “C” (2.00) or higher before enrolling in any course that requires that mathematics or physics course as a prerequisite. The student must also have an overall GPA of at least 2.00 for the following group of courses: CSE 100; ECE 201, 300, 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 87.

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)	
— or —	
ENG 105 Advanced First-Year Composition (3)	
Elective (requires departmental approval) (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 courses	6–9
SB course(s)	3–6
Minimum total	15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L</i>	3
EEE 488 Senior Design Laboratory I <i>L</i> ²	2
EEE 489 Senior Design Laboratory II <i>L</i> ²	2
Total	7

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers <i>SQ</i>	4
or CHM 116 General Chemistry <i>SQ</i> (4)	
PHY 121 University Physics I: Mechanics <i>SQ</i> ^{1,3}	3
PHY 122 University Physics Laboratory I <i>SQ</i> ^{1,3}	1
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ^{1,4}	3
PHY 132 University Physics Laboratory II <i>SQ</i> ^{1,4}	1
PHY 241 University Physics III ¹	3
Total	15

Mathematical Studies

ECE 100 Introduction to Engineering Design <i>CS</i>	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i> ¹	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i> ¹	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i> ¹	4
MAT 274 Elementary Differential Equations <i>MA</i> ¹	3
or MAT 275 Modern Differential Equations <i>MA</i> ¹ (3)	
MAT 342 Linear Algebra ¹	3
or MAT 343 Applied Linear Algebra ¹ (3)	
MAT 362 Advanced Mathematics for Engineers and Scientists ¹	3
Total	24
General Studies/school requirements total	61

¹ L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

Engineering Core

ECE 201 Electrical Networks I	4
ECE 214 Engineering Mechanics	4
ECE 334 Electronic Circuits	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” (2.00) is required.

² Both EEE 488 and 489 must be taken to secure L credit.

³ Both PHY 121 and 122 must be taken to secure SQ credit.

⁴ Both PHY 131 and 132 must be taken to secure SQ credit.

Electrical Engineering Major

The following courses are required to fulfill the Electrical Engineering major:

CSE 100 Principles of Programming with C++ CS*	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

* CSE 110 Principles of Programming with Java (3) can be substituted for CSE 100 with Department of Electrical Engineering approval.

The program in Electrical Engineering requires a total of 18 semester 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 seven areas. In addition, to ensure depth, two courses must be taken in one area.

Communications and Signal Processing

EEE 407 Digital Signal Processing	4
EEE 455 Communication Systems	4
EEE 459 Communication Networks	3

Computer Engineering

CSE 330 Computer Organization and Architecture	3
CSE 420 Computer Architecture I	3
CSE 421 Microprocessor System Design I	4
CSE 422 Microprocessor System Design II	4

Controls

EEE 480 Feedback Systems	4
EEE 482 Introduction to State Space Methods	3

Electromagnetics

EEE 440 Electromagnetic Engineering II	4
EEE 443 Antennas for Wireless Communications	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	4

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

Electrical Engineering Program of Study Typical Four-Year Sequence

First Year

First Semester

CHM 114 General Chemistry for Engineers SQ	4
or CHM 116 General Chemistry SQ (4)	—
ECE 100 Introduction to Engineering Design CS ¹	3
or EEE 120 Digital Design Fundamentals (3)	—
ENG 101 First-Year Composition	3
MAT 270 Calculus with Analytic Geometry I MA	4
Total	14

Second Semester

EEE 120 Digital Design Fundamentals ¹	3
or ECE 100 Introduction to Engineering Design CS (3)	—
ENG 102 First-Year Composition	3
MAT 271 Calculus with Analytic Geometry II MA	4
PHY 121 University Physics I: Mechanics SQ ²	3
PHY 122 University Physics Laboratory I SQ ²	1
Total	14

Second Year

First Semester

CSE 100 Principles of Programming with C++ CS ³	3
ECN 111 Macroeconomic Principles SB	3
or ECN 112 Microeconomic Principles SB (3)	—
MAT 272 Calculus with Analytic Geometry III MA	4
MAT 274 Elementary Differential Equations MA	3
or MAT 275 Modern Differential Equations MA (3)	—
PHY 131 University Physics II: Electricity and Magnetism SQ ⁴	3
PHY 132 University Physics Laboratory II SQ ⁴	1
Total	17

Second Semester

ECE 201 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	3
PHY 241 University Physics III	3
HU/SB and awareness area course ⁵	3
Total	17

Third Year

First Semester

ECE 334 Electronic Circuits	4
EEE 302 Electrical Networks II	3
EEE 340 Electromagnetic Engineering I	4
MAT 342 Linear Algebra	3
or MAT 343 Applied Linear Algebra (3)	
HU/SB and awareness area course ⁵	3
Total	17

Second Semester

ECE 300 Intermediate Engineering Design L	3
ECE 352 Properties of Electronic Materials	4
EEE 303 Signals and Systems.....	3
EEE 360 Energy Conversion and Transport.....	4
HU/SB and awareness area course ⁵	3
Total	17

Fourth Year

First Semester

ECE 214 Engineering Mechanics.....	4
EEE 350 Random Signal Analysis.....	3
EEE 488 Senior Design Laboratory I L ⁶	2
Technical electives	7
Total	16

Second Semester

EEE 489 Senior Design Laboratory II L ⁶	2
HU/SB and awareness area course ⁵	3
Technical electives	11
Total	16

- ¹ Both ECE 100 and 120 are required.
- ² Both PHY 121 and 122 must be taken to secure SQ credit.
- ³ CSE 110 Principles of Programming with Java (3) can be substituted for CSE 100 with Department of Electrical Engineering approval.
- ⁴ Both PHY 131 and 132 must be taken to secure SQ credit.
- ⁵ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.
- ⁶ Both EEE 488 and 489 must be taken to secure L credit.

ELECTRICAL ENGINEERING (EEE)

EEE 120 Digital Design Fundamentals. (3)

fall and spring
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. Fee. Prerequisite: computer literacy.

EEE 225 Assembly Language Programming and Microprocessors (Motorola). (4)

fall and spring
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. Fee. Prerequisites: CSE 100 (or 110 or 200); CSE 120 or EEE 120.

EEE 226 Assembly Language Programming and Microprocessors (Intel). (4)

fall and spring
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. Fee. Prerequisites: CSE 100 (or 110 or 200); CSE 120 or EEE 120.

EEE 302 Electrical Networks II. (3)

fall, spring, summer
Analyzes linear and nonlinear networks. Analytical and numerical methods. Prerequisite: ECE 201. Pre- or corequisite: MAT 362.

EEE 303 Signals and Systems. (3)

fall, spring, summer
Introduces continuous and discrete time signal and system analysis, linear systems, Fourier, and z-transforms. Prerequisite: EEE 302. Pre- or corequisite: MAT 342 or 343.

EEE 340 Electromagnetic Engineering I. (4)

fall and spring
Static and time varying vector fields; boundary value problems; dielectric and magnetic materials; Maxwell's equations; boundary conditions. Prerequisites: ECE 201; MAT 362; PHY 131, 132.

EEE 350 Random Signal Analysis. (3)

fall and spring
Probabilistic and statistical analysis as applied to electrical signals and systems. Pre- or corequisite: EEE 303.

EEE 360 Energy Conversion and Transport. (4)

fall and spring
Three-phase circuits. Energy supply systems. Magnetic circuit analysis, synchronous generators, transformers, induction and DC machines. Transmission line modeling and design. Lecture, lab. Fee. Prerequisite: EEE 302.

EEE 405 Filter Design. (3)

fall
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)

fall and spring
Time and frequency domain analysis, difference equations, z-transform, FIR and IIR digital filter design, discrete Fourier transform, FFT, and random sequences. Lecture, lab. Fee. Prerequisites: EEE 303; MAT 342 (or 343).

EEE 425 Digital Systems and Circuits. (4)

fall and spring
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. Fee. Prerequisite: ECE 334.

EEE 433 Analog Integrated Circuits. (4)

fall and spring
Analysis, design, and applications of modern analog circuits using integrated bipolar and field effect transistor technologies. Lecture, lab. Fee. Prerequisite: ECE 334.

EEE 434 Quantum Mechanics for Engineers. (3)

fall
Angular momentum, wave packets, Schrodinger 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)

spring
Introduces basic CMOS processing and fabrication tools. Covers the fundamentals of thermal oxidation, CVD, implantation, diffusion, and process integration. Internet lecture, Internet or on-campus lab. Fee. Pre- or corequisite: EEE 436.

EEE 436 Fundamentals of Solid-State Devices. (3)

fall and spring
Semiconductor fundamentals, pn junctions, metal-semiconductor contacts, metal-oxide-semiconductor capacitors and field-effect transistors, bipolar junction transistors. Prerequisite: ECE 352.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

EEE 437 Optoelectronics. (3)

selected semesters

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)

fall

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)

spring

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. Fee. Prerequisite: EEE 340.

EEE 443 Antennas for Wireless Communications. (3)

spring

Fundamental parameters; radiation integrals; wireless systems; wire, loop, and microstrip antennas; antenna arrays; smart antennas; ground effects; multipath. Prerequisite: EEE 340.

EEE 445 Microwaves. (4)

fall

Waveguides; circuit theory for waveguiding systems; microwave devices, systems, and energy sources; striplines and microstrips; impedance matching transformers; measurements. Lecture, lab. Fee. Prerequisite: EEE 340.

EEE 448 Fiber Optics. (4)

fall

Principles of fiber-optic communications. Lecture, lab. Fee. Prerequisites: EEE 303, 340.

EEE 455 Communication Systems. (4)

fall and spring

Signal analysis techniques applied to the operation of electrical communication systems. Introduction to and overview of modern digital and analog communications. Lecture, lab. Fee. Prerequisite: EEE 350.

EEE 459 Communication Networks. (3)

spring

Fundamentals of communication networks. Study of Seven-Layer OSI model. Focus on functionality and performance of protocols used in communication networks. Prerequisite: EEE 350.

EEE 460 Nuclear Concepts for the 21st Century. (3)

spring

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)

fall

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 201, 340 (or PHY 241).

EEE 470 Electric Power Devices. (3)

fall

Analyzes 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)

spring

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)

fall

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)

fall and spring

Analysis and design of linear feedback systems. Frequency response and root locus techniques, series compensation, and state variable feedback. Lecture, lab. Fee. Prerequisite: EEE 303.

EEE 482 Introduction to State Space Methods. (3)

fall

Discrete and continuous systems in state space form controllability, stability, and pole placement. Observability and observers. Pre- or corequisite: EEE 480.

EEE 488 Senior Design Laboratory I. (2)

fall and spring

Capstone senior project. Design process: research, concept, feasibility, simulation, specifications, benchmarking, and proposal generation. Technical communications and team skills enrichment. Lecture, lab. Fee. Prerequisites: ECE 300, 334; EEE 303, 340; senior standing. Pre- or corequisite: ECE 352; EEE 360.

General Studies: L (if credit also earned in EEE 489)

EEE 489 Senior Design Laboratory II. (2)

fall and spring

Capstone senior project. Implement, evaluate, and document EEE 488 design. Social, economic, and safety considerations. Technical communications and team skills enrichment. Lecture, lab. Fee. Prerequisite: EEE 488 in the immediately preceding semester.

General Studies: L (if credit also earned in EEE 488)

EEE 492 Honors Directed Study. (1–6)

selected semesters

EEE 493 Honors Thesis. (1–6)

selected semesters

EEE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Department of Industrial Engineering

www.eas.asu.edu/~ie

480/965-3185

GWC 502

Gary L. Hogg, Chair

Professors: Cochran, Fowler, Henderson, Hogg, Hubele, Montgomery, Runger, Shunk, Wolfe, Ye

Associate Professors: Anderson-Rowland, Mackulak, Moor, Roberts, Villalobos

Assistant Professors: Gel, Keha, Kulahci, Wu

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 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 looking 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. IEs 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.

The curriculum in Industrial Engineering builds upon mathematics, computer utilization, and the engineering core. Beyond this foundation, the curriculum includes a number of required IE core courses, IE electives, and study area electives, enabling each student to focus on a specific career objective.

By successfully completing this curriculum, the student is prepared to embark on a career in industrial engineering or to pursue advanced education in graduate school.

The career-focused study areas are as follows:

1. *Industrial and Management Systems.* For a broad traditional IE career in the design and analysis of manufacturing and service systems.
2. *Information and Telecommunication Systems.* For a career in the application of integrated computer and telecommunication systems to manufacturing and service systems analysis and design.
3. *Global Industrial Engineering Leadership.* For a career in global manufacturing and service organizations.
4. *High-Tech Manufacturing.* For a career in the design and analysis of integrated manufacturing systems.
5. *Preprofessional and Service Systems.* For a career in law, medicine or public service or careers in the design and analysis of health care, agribusiness, banking/financial, and government/public-administration systems.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Industrial Engineering. A minimum of 50 upper-division hours is required. Students must attain a GPA of at least 2.00 for the courses in the major field.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See “University Graduation Requirements,” page 87. For information concerning admission, degree, course, and graduation requirements for the School of Engineering, see “Admission,” page 219, and subsequent sections.

COURSE REQUIREMENTS

Students take 59 semester hours of university English proficiency and general studies course work, 19 hours of engineering core, 35 hours of industrial engineering courses, three hours of industrial engineering electives, and 12 hours of career-focused study area electives. Each study area has an associated list of recommended General Studies, IE electives, and study area courses. The course work for

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

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 112 Microeconomic Principles <i>SB</i>	3
or ECN 111 Macroeconomic Principles <i>SB</i> (3)	
HU courses	6–9
SB course(s)	3–6
Minimum total	15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L</i>	3
IEE 490 Project in Design and Development <i>L</i>	3
Total	6

Natural Sciences/Basic Sciences

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

Mathematical Studies

MAT 242 Elementary Linear Algebra	2
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
Total	17
General Studies/school requirements total	53

Engineering Core

ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECE 201 Electrical Networks I	4
ECE 210 Engineering Mechanics I: Statics	3
ECE 212 Engineering Mechanics II: Dynamics	3
ECE 350 Structure and Properties of Materials	3
IEE 463 Computer-Aided Manufacturing and Control <i>CS</i>	3
Total	19

¹ Both PHY 121 and 122 must be taken to secure *SQ* credit.

² Both PHY 131 and 132 must be taken to secure *SQ* credit.

Industrial Engineering Major

The following courses are required:

CSE 100 Principles of Programming with C++ <i>CS</i>	3
or CSE 110 Principles of Programming with Java (3)	
CSE 200 Concepts of Computer Science <i>CS</i>	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3

IEE 294 ST: Industrial Engineering Applications Seminar	2
IEE 300 Economic Analysis for Engineers	3
IEE 360 Manufacturing Processes	3
IEE 368 Facilities Analysis and Design	3
or IEE 369 Work Analysis and Design (3)	
IEE 376 Operations Research Deterministic Techniques/Applications <i>CS</i>	3
IEE 385 Introduction to Engineering Probability Models <i>CS</i>	3
IEE 461 Production Control	3
IEE 474 Quality Control <i>CS</i>	3
IEE 475 Simulating Stochastic Systems <i>CS</i>	3
Total	35

Industrial Engineering Electives Area

Students select three semester hours of industrial engineering electives. IEE 361 Manufacturing Processes Lab is highly recommended. For course information, see the list of recommended courses in the department advising office.

Career-Focused Study Area Electives

Students select a minimum of 12 semester hours from the following recommended electives in one of the five career-focused study areas.

Industrial and Management Systems

IEE 305 Information Systems Engineering <i>CS</i>	3
IEE 431 Engineering Administration	3
Any approved engineering or business elective	3
Any approved engineering elective	3

Information and Telecommunication Systems

CSE 210 Object-Oriented Design and Data Structures <i>CS</i>	3
CSE 240 Introduction to Programming Languages	3
IEE 305 Information Systems Engineering <i>CS</i>	3
IEE 494 ST: Information Systems Development Tools	3

Global Industrial Engineering Leadership

ECN 306 Survey of International Economics <i>SB, G</i>	3
IBS 300 Principles of International Business <i>G</i>	3
IBS 400 Cultural Factors in International Business <i>C, G</i>	3
Any approved international business electives	3

High-Tech Manufacturing¹

ECE 352 Properties of Electronic Materials	4
EEE 435 Microelectronics	3
EEE 436 Fundamentals of Solid-State Devices	3
MSE 355 Introduction to Materials Science and Engineering	3
MSE 441 Analysis of Materials Failures	3
MSE 470 Polymers and Composites	3

Preprofessional and Service Systems^{1, 2}

Focus area courses	12
--------------------	----

¹ Certain focus areas may require more than 12 semester hours due to course prerequisites.

² A student desiring a focus area other than those listed is invited to create his or her own that concentrates on a professional service area. The student is expected to formulate a set of four courses (12 semester hours) that supports his or her career option. The student needs to submit a petition to the department that explains and supports the focus and the courses selected. The associate chair for undergraduate studies must approve the petition before the student begins study in the focus area. For more information, see the IE academic advisor.

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

First Year

First Semester

CHM 114	General Chemistry for Engineers <i>SQ</i>	4
	or CHM 116 General Chemistry <i>SQ</i> ¹	
ECE 100	Introduction to Engineering Design <i>CS</i>	3
ENG 101	First-Year Composition.....	3
MAT 270	Calculus with Analytic Geometry I <i>MA</i>	4
Total	.....	14

Second Semester

ECN 112	Microeconomic Principles <i>SB</i>	3
	or ECN 111 Macroeconomic Principles <i>SB</i> (3).....	
ENG 102	First-Year Composition.....	3
MAT 271	Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121	University Physics I: Mechanics <i>SQ</i> ²	3
PHY 122	University Physics Laboratory I <i>SQ</i> ²	1
HU/SB elective ³	.....	3
Total	.....	17

Second Year

First Semester

CSE 100	Principles of Programming with C++ <i>CS</i>	3
	or CSE 110 Principles of Programming with Java <i>CS</i> (3).....	
IEE 300	Economic Analysis for Engineers.....	3
MAT 242	Elementary Linear Algebra.....	2
MAT 272	Calculus with Analytic Geometry III <i>MA</i>	4
PHY 131	University Physics II: Electricity and Magnetism <i>SQ</i> ⁴	3
PHY 132	University Physics Laboratory II <i>SQ</i> ⁴	1
Total	.....	16

Second Semester

CSE 200	Concepts of Computer Science <i>CS</i>	3
ECE 350	Structure and Properties of Materials.....	3
ECE 380	Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
IEE 294	ST: Industrial Engineering Applications Seminar.....	2
MAT 274	Elementary Differential Equations <i>MA</i>	3
Basic science elective ⁵	.....	3
Total	.....	17

Third Year

First Semester

ECE 201	Electrical Networks I.....	4
ECE 210	Engineering Mechanics I: Statics.....	3
IEE 360	Manufacturing Processes.....	3
IEE 385	Introduction to Engineering Probability Models <i>CS</i>	3
IEE 474	Quality Control <i>CS</i>	3
Total	.....	16

Second Semester

ECE 212	Engineering Mechanics II: Dynamics.....	3
ECE 300	Intermediate Engineering Design <i>L</i>	3
IEE 376	Operations Research Deterministic Techniques/Applications <i>CS</i>	3
IEE 463	Computer-Aided Manufacturing and Control <i>CS</i>	3
Study area elective	.....	3
Total	.....	15

Fourth Year

First Semester

IEE 368	Facilities Analysis and Design.....	3
	or IEE 369 Work Analysis and Design (3).....	

IEE 461	Production Control.....	3
IEE 475	Simulating Stochastic Systems <i>CS</i>	3
HU/SB elective ³	.....	3
Study area elective	.....	3
Industrial engineering elective	.....	3
Total	.....	18

Second Semester

IEE 490	Project in Design and Development.....	3
HU/SB elective ³	.....	6
Study area electives	.....	6
Total	.....	15

- 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 *SQ* 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 *SQ* credit.
- 5 This elective 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 ENGINEERING (IEE)

IEE 294 Special Topics. (1–4)

fall and spring

Topics may include the following:

- Industrial Engineering Applications Seminar. (2)

IEE 300 Economic Analysis for Engineers. (3)

fall, spring, summer

Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Prerequisites: ECE 100; MAT 270.

IEE 305 Information Systems Engineering. (3)

fall

Overview of computer and information systems applications. Topics include client/server; distributed computing; networks; process modeling; e-commerce; enterprise applications; Internet. Fee. Prerequisite: CSE 200.

General Studies: CS

IEE 360 Manufacturing Processes. (3)

fall and spring

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. Fee. Prerequisite: ECE 350.

IEE 361 Manufacturing Processes Lab. (1)

fall and spring

Series of labs designed to illustrate concepts presented in IEE 360 on production technique and equipment. Fee. Corequisite: IEE 360 or MAE 351.

IEE 368 Facilities Analysis and Design. (3)

fall

Planning, analysis, and design of the tangible physical assets of the firm. Emphasizes facilities location, materials handling, automation, computer integration, and utilization of financial resources. Applications in diverse fields. Lecture, lab. Fee. Prerequisite: IEE 300.

IEE 369 Work Analysis and Design. (3)

spring

Planning, analysis, and design of methods of accomplishing work. Emphasizes human factors, work planning, methods analysis and design, and work measurement. Applications in diverse fields. Lecture, lab. Fee. Prerequisite: IEE 300.

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

IEE 376 Operations Research Deterministic Techniques/Applications. (3)

fall and spring

Industrial systems applications with deterministic operations research techniques. Resource allocation, product mix, production, transportation, task assignment, networks. Prerequisites: CSE 200; MAT 242.

General Studies: CS

IEE 385 Introduction to Engineering Probability Models. (3)

fall, spring, summer

Elements of probability modelling with engineering applications. Topics include probability distributions, properties of distributions, Markov chains, queuing, and reliability. Prerequisite: ECE 380.

General Studies: CS

IEE 394 Special Topics. (1–4)

fall and spring

Topics may include the following:

- Introduction to Manufacturing Engineering (Intel). (3)

IEE 431 Engineering Administration. (3)

fall and summer

Introduces quantitative and qualitative approaches to management functions, engineering administration, organizational analysis, decision making, and communication. Credit is allowed for only IEE 431 or 541. Prerequisite: senior standing.

IEE 437 Human Factors Engineering. (3)

fall

Study of the human psychological and physiological factors that underlie the design of equipment and the interaction between people and machines. Credit is allowed for only IEE 437 or 547.

IEE 461 Production Control. (3)

fall

Techniques for the planning, control, and evaluation of production systems. Project management, forecasting, inventory control, scheduling, enterprise requirements planning. Prerequisites: CSE 100 (or 110); IEE 376, 385.

IEE 463 Computer-Aided Manufacturing and Control. (3)

spring

Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning, and robotics. Credit is allowed for only IEE 463 or 543. Fee. Prerequisite: IEE 360 or MAE 351.

General Studies: CS

IEE 474 Quality Control. (3)

fall

Basic statistical process control techniques, capability analysis, design of experiments, and acceptance sampling plans. Prerequisite: IEE 385.

General Studies: CS

IEE 475 Simulating Stochastic Systems. (3)

fall and spring

Analyzes stochastic systems using basic queuing networks and discrete event simulation. Basic network modeling, shared resources, routing, assembly logic. Prerequisites: CSE 200; IEE 385.

General Studies: CS

IEE 490 Project in Design and Development. (3)

fall and spring

Individual or team capstone project in creative design and synthesis. Fee. Prerequisites: IEE 376, 475.

General Studies: L

IEE 492 Honors Directed Study. (1–6)

selected semesters

IEE 493 Honors Thesis. (1–6)

selected semesters

IEE 494 Special Topics. (1–4)

fall and spring

Topics may include the following:

- Information Systems Development Tools. (3)

IEE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see “Omnibus Courses,” page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see “Graduate-Level Courses,” page 62.

Department of Mechanical and Aerospace Engineering

www.fulton.asu.edu/~mae

480/965-3291

ECG 346

Robert E. Peck, Chair

Aerospace Engineering

Professors: Chattopadhyay, Liu, Mignolet, Reed, Saric, Wie

Associate Professors: Lee, Wells

Assistant Professor: Mikellides

Mechanical Engineering

Professors: Boyer, Davidson, Fernando, Peck, Roy, Shah, Sieradzki, Squires, Tseng, Yao

Associate Professors: Chen, Kuo, McNeill, Phelan, Van Schilfgaarde

Assistant Professors: Calhoun, Peralta, Sugar

The Department of Mechanical and Aerospace Engineering is the administrative home for two undergraduate majors: Aerospace Engineering and Mechanical Engineering. Consistent with the department’s mission to provide the best possible education to its students, a department goal is to attract and retain—from the metropolitan community, the state, and the country—outstanding and diverse students and to give each the opportunity to become competent in contemporary subjects that bear on an engineering career.

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 in aerospace industries or at government laboratories (e.g., NASA). 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 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 a rapidly changing technical society.

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. Astronautics topics such as orbital mechanics, attitude dynamics, spacecraft control, and rocket propulsion are also covered in required courses.

The aerospace engineering curriculum is designed to accomplish four objectives:

1. *Technical Competency.* Graduates have an understanding of the fundamental principles of mathematics, physics, and chemistry and will use this knowledge to model and predict the behavior of aerospace engineering systems.
2. *Design Aptitude.* Graduates gain the ability to design a system appropriate to the field of aerospace engineering. Graduates perform conceptual and preliminary design of aircraft systems or subsystems. This takes into account life-cycle cost and environmental impact in the design process.
3. *Communication Skills.* Graduates are skilled at making effective oral and written technical presentations and documenting analysis and design processes.
4. *Professionalism.* Graduates have the professional attributes necessary for success in the current work environment. They will be prepared for modern engineering practice by effectively working in teams, showing a propensity for maintaining technical currency, and having an understanding of related global, ethical, environmental, and societal issues.

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 one-half year 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.

DEGREE REQUIREMENTS

A minimum of 128 semester hours of course work is necessary for the B.S.E. degree in Aerospace Engineering, including a minimum of 50 upper-division semester hours. All students must satisfy the university First-Year Composi-

tion Requirement and General Studies requirement. The Fulton School of Engineering does not permit the use of pass/fail classes as part of a degree program, and at the option of the department, courses taken more than five years before admission to the programs are normally not accepted for transfer credit.

GRADUATION REQUIREMENTS

A student must earn a grade of “C” (2.00) or higher in all lower-division mathematics, physics, and chemistry courses and in the engineering core. A student must attain a minimum GPA of 2.00, in the major and overall. The department may require additional or remedial course work for those students who have demonstrated a trend toward academic difficulties.

COURSE REQUIREMENTS

The specific course requirements for the B.S.E. degree in Aerospace Engineering are as follows:

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)	
Approved elective (3)	
————— <i>or</i> —————	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	

Total6

General Studies/School Requirements²

<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 courses.....	6-9
<i>SB</i> course(s).....	3-6
Minimum total	15
<i>Literacy and Critical Inquiry</i>	
ECE 300 Intermediate Engineering Design <i>L</i>	3
MAE 468 Aerospace Systems Design <i>L</i>	3
Total	6

<i>Natural Sciences/Basic Sciences</i>	
CHM 114 General Chemistry for Engineers <i>SQ</i> ¹	4
or CHM 116 General Chemistry <i>SQ</i> ¹ (4)	
PHY 121 University Physics I: Mechanics <i>SQ</i> ^{1,3}	3
PHY 122 University Physics Laboratory I <i>SQ</i> ^{1,3}	1
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ^{1,4}	3
PHY 132 University Physics Laboratory II <i>SQ</i> ^{1,4}	1
PHY 361 Introductory Modern Physics.....	3
Total	15

<i>Mathematical Studies</i>	
MAT 242 Elementary Linear Algebra ¹	2
MAT 270 Calculus with Analytic Geometry I <i>MA</i> ¹	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i> ¹	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i> ¹	4

¹ L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/ quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See “General Studies,” page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

MAT 274 Elementary Differential Equations <i>MA</i> ¹	3
Total	17
General Studies school requirements total.....	53
Engineering Core⁵	
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECE 201 Electrical Networks I	4
ECE 210 Engineering Mechanics I: Statics.....	3
ECE 212 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	22
Aerospace Engineering Major⁶	
ECE 384 Numerical Methods for Engineers	4
MAE 101 Introduction to Aerospace Engineering ⁷	2
MAE 317 Dynamic Systems and Control.....	3
MAE 319 Measurements and Data Analysis	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
Design technical elective (Select at least one).....	3
MAE 426 Design of Aerospace Structures (3)	
MAE 465 Rocket Propulsion (3)	
MAE 466 Rotary Wing Aerodynamics and Performance (3)	
MAE 467 Aircraft Performance (3)	
MAE 469 Projects in Astronautics or Aeronautics (3)	
Technical elective(s).....	3
Total	47
<i>Total for the program</i>	128

¹ A minimum grade of “C” (2.00) is required.

² The General Studies requirement is divided into five core and three awareness areas. A student must include within his or her program at least two courses that cover the three awareness areas. It is recommended that students consult an academic advisor to ensure the completion of the Humanities and Fine Arts (HU), Social and Behavior Sciences (SB), and awareness areas (C, G, H).

³ Both PHY 121 and 122 must be taken to secure SQ credit.

⁴ Both PHY 131 and 132 must be taken to secure SQ credit.

⁵ A minimum grade of “C” (2.00) is required. With engineering core courses that are prerequisite to any course in the Aerospace Engineering major, a student must attain a minimum grade of “C” in order to receive prerequisite credit.

⁶ A “C” (2.00) average or higher is required for all classes listed under the major plus MAE 468.

⁷ Required for incoming first-year students. Transfer students with sophomore status should not register for MAE 101 but must take an additional two semester hours of approved technical electives.

Aerospace Engineering Areas of Study

The technical elective(s) may be selected from among any of the courses on the following list. A student may, with prior approval of the advisor and department chair, select a course not listed that would support a specific career objective. Graduate-level courses are permitted provided the stu-

dent has at least a 3.00 GPA and approval of the instructor, advisor, and the college dean.

IEE 300 Economic Analysis for Engineers.....	3
IEE 385 Introduction to Engineering Probability Models <i>CS</i>	3
IEE 463 Computer-Aided Manufacturing and Control <i>CS</i>	3
MAE 341 Mechanism Analysis and Design.....	3
MAE 351 Manufacturing Processes	3
MAE 372 Fluid Mechanics.....	3
MAE 388 Heat Transfer.....	3
MAE 404 Finite Elements in Engineering.....	3
MAE 406 CAD/CAM Applications in MAE.....	4
MAE 417 Control System Design	3
MAE 434 Internal Combustion Engines.....	3
MAE 435 Turbomachinery	3
MAE 447 Robotics and Its Influence on Design	3
MAE 455 Polymers and Composites.....	3
MAE 461 Aerodynamics II.....	3
MAE 471 Computational Fluid Dynamics	3
MAT 421 Applied Computational Methods <i>CS</i>	3
MAT 423 Numerical Analysis I <i>CS</i>	3
MAT 425 Numerical Analysis II <i>CS</i>	3
MSE 440 Mechanical Properties of Solids	3
MSE 441 Analysis of Material Failures.....	3

TYPICAL FOUR-YEAR SEQUENCE

The first two years are usually devoted to the General Studies and engineering core requirements. 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 <i>SQ</i>	4
or CHM 116 General Chemistry <i>SQ</i> (4)	
ECE 100 Introduction to Engineering Design <i>CS</i>	3
or HU/SB elective ¹ (3)	
ENG 101 First-Year Composition.....	3
MAE 101 Introduction to Aerospace Engineering	2
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	16

Second Semester

ENG 102 First-Year Composition.....	3
MAT 242 Elementary Linear Algebra	2
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ²	3
PHY 122 University Physics Laboratory I <i>SQ</i> ²	1
HU/SB and awareness area course ¹	3
or ECE 100 Introduction to Engineering Design <i>CS</i> (3)	
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>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ³	3
PHY 132 University Physics Laboratory II <i>SQ</i> ³	1
Total	17

Second Semester

ECE 201 Electrical Networks I	4
ECE 212 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 340 Thermodynamics.....	3
ECE 384 Numerical Methods for Engineers.....	4
Total	17

Third Year

First Semester

ECE 300 Intermediate Engineering Design L	3
MAE 317 Dynamic Systems and Control.....	3
MAE 319 Measurements and Data Analysis	3
MAE 361 Aerodynamics I.....	3
MAE 425 Aerospace Structures	4
Total	16

Second Semester

MAE 413 Aircraft Performance, Stability, and Control	3
MAE 444 Fundamentals of Aerospace Design.....	3
MAE 460 Gas Dynamics	3
PHY 361 Introductory Modern Physics.....	3
HU/SB and awareness area course ¹	3
Total	15

Fourth Year

First Semester

MAE 415 Vibration Analysis.....	4
MAE 462 Space Vehicle Dynamics and Control	3
MAE 463 Propulsion	3
MAE 464 Aerospace Laboratory	3
HU/SB and awareness area course ¹	3
Total	16

Second Semester

MAE 468 Aerospace Systems Design L.....	3
HU/SB and awareness area courses ¹	6
Required design technical elective.....	3
Technical elective.....	3
Total	15

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

² Both PHY 121 and 122 must be taken to secure SQ credit.

³ Both PHY 131 and 132 must be taken to secure SQ 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 such as heat exchangers, pipelines, gears, and linkages; and 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 hardware 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 in seeking new knowledge through research, in generating creative design and development, and in the production, 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.

The curriculum is designed to accomplish the following four objectives:

1. *Technical Competency.* Graduates are able to model and predict the behavior of engineering systems by applying the fundamental principles from mathematics, physics, and chemistry and by using modern computational and experimental tools.
2. *Product Realization Ability.* Graduates are able to design components or systems at the conceptual and embodiment design level including the issues of production, manufacturability, and cost.
3. *Communication Skills.* Graduates can present and document effectively, using both oral and written communication, their work and ideas to a diverse audience.
4. *Professionalism.* Graduates are prepared for modern engineering practice by working in teams, keeping technologically abreast, and having an understanding of related ethical, environmental, and societal issues.

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.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Mechanical Engineering, including a

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

minimum of 50 upper-division semester hours. All students must satisfy the university First-Year Composition requirement and General Studies requirement. The Fulton School of Engineering does not permit the use of pass/fail classes as part of a degree program, and at the option of the department, courses taken more than five years before admission to the programs are normally not accepted for transfer credit.

GRADUATION REQUIREMENTS

A student must earn a grade of “C” (2.00) or higher in all lower-division mathematics, physics, and chemistry courses, and in the engineering core. A student must attain a minimum GPA of 2.00 in the major and overall. The department may require additional or remedial course work for those students who have demonstrated a trend toward academic difficulties.

COURSE REQUIREMENTS

The specific course requirements for the B.S.E. degree in Mechanical Engineering are as follows:

First-Year Composition¹

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)	
Approved elective (3)	
-----or-----	
ENG 107 English for Foreign Students (3)	
ENG 108 English for Foreign Students (3)	
Total	6

General Studies/School Requirements²

<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 courses	6-9
SB course(s)	3-6
Minimum total	15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design <i>L</i>	3
MAE 490 Projects in Design and Development <i>L</i>	3
Total	6

Natural Sciences/Basic Sciences

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

Mathematical Studies

MAT 242 Elementary Linear Algebra ¹	2
MAT 270 Calculus with Analytic Geometry I <i>MA</i> ¹	4
MAT 271 Calculus with Analytic Geometry II <i>MA</i> ¹	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i> ¹	4

MAT 274 Elementary Differential Equations <i>MA</i> ¹	3
Total	17
General Studies school requirements total	53

Engineering Core⁵

ECE 100 Introduction to Engineering Design <i>CS</i>	3
ECE 201 Electrical Networks I	4
ECE 210 Engineering Mechanics I: Statics	3
ECE 212 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	22

Mechanical Engineering Major⁶

ECE 384 Numerical Methods for Engineers	4
MAE 317 Dynamic Systems and Control	3
MAE 319 Measurements and Data Analysis	3
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 491 Experimental Mechanical Engineering	3
Mechanical systems design (select one)	3-4
MAE 341 Mechanism Analysis and Design (3)	
MAE 442 Mechanical Systems Design (4)	
MAE 447 Robotics and Its Influence on Design (3)	
Thermal systems design (select one)	3
MAE 382 Thermodynamics (3)	
MAE 433 Air Conditioning and Refrigeration (3)	
MAE 434 Internal Combustion Engines (3)	
MAE 435 Turbomachinery (3)	
MAE 446 Thermal Systems Design (3)	
Areas of study (technical electives)	11-12
Total	47
Total for the program	128

¹ A minimum grade of “C” (2.00) or higher is required.

² The General Studies requirement is divided into five core and three awareness areas. A student must include within his or her program at least two courses that cover the three awareness areas. It is recommended that students consult an academic advisor to ensure completion of the Humanities and Fine Arts (HU), Social and Behavioral Sciences (SB), and awareness areas (C, G, H).

³ Both PHY 121 and 122 must be taken to secure *SQ* credit.

⁴ Both PHY 131 and 132 must be taken to secure *SQ* credit.

⁵ A minimum grade of “C” (2.00) is required. With engineering core courses that are prerequisite to any course in the Mechanical Engineering major, a student must attain a minimum grade of “C” in order to receive prerequisite credit.

⁶ A GPA of 2.00 or higher is required for all classes listed under the major plus MAE 490.

Mechanical Engineering Areas of Study. Technical electives may be selected from among any of the following courses. The courses are grouped to assist a student in identifying areas of specialization. Students preferring a broader technical background may choose courses from different areas. Generally no more than two technical elective courses from outside the department area are allowed. Furthermore, only one project course may be used for a technical elective. Graduate-level classes may be used provided the student’s GPA is at least 3.00 and the student has permission from the

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

course instructor, department advisor, and the Fulton School of Engineering dean. Credit for courses not on the list requires prior approval of the student's advisor and department.

Aerospace

MAE 413 Aircraft Performance, Stability, and Control	3
MAE 415 Vibration Analysis	4
MAE 426 Design of Aerospace Structures	3
MAE 455 Polymers and Composites	3
MAE 460 Gas Dynamics	3
MAE 461 Aerodynamics II	3
MAE 463 Propulsion	3
MAE 465 Rocket Propulsion	3
MAE 466 Rotary Wing Aerodynamics and Performance	3
MAE 467 Aircraft Performance	3
MAE 469 Projects in Astronautics or Aeronautics	3

Biomechanical

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

CSE 310 Data Structures and Algorithms	3
CSE 422 Microprocessor System Design II	4
CSE 428 Computer-Aided Processes	3
IEE 385 Introduction to Engineering Probability Models	3
IEE 463 Computer-Aided Manufacturing and Control CS	3
IEE 475 Simulating Stochastic Systems CS	3
MAE 404 Finite Elements in Engineering	3
MAE 406 CAD/CAM Applications in MAE	4
MAE 471 Computational Fluid Dynamics	3
MAT 421 Applied Computational Methods CS	3
MAT 423 Numerical Analysis I CS	3
MAT 425 Numerical Analysis II CS	3

Control and Dynamic Systems

CSE 428 Computer-Aided Processes	3
EEE 360 Energy Conversion and Transport	4
EEE 480 Feedback Systems	4
EEE 482 Introduction to State Space Methods	3
IEE 463 Computer-Aided Manufacturing and Control CS	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

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	4
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

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

MAE 341 Mechanism Analysis and Design	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	4
MAE 460 Gas Dynamics	3
MAE 461 Aerodynamics II	3
MAE 471 Computational Fluid Dynamics	3
MAT 421 Applied Computational Methods CS	3
MAT 423 Numerical Analysis I CS	3
MSE 440 Mechanical Properties of Solids	3

Manufacturing

CSE 428 Computer-Aided Processes	3
IEE 300 Economic Analysis for Engineers	3
IEE 461 Production Control	3
IEE 463 Computer-Aided Manufacturing and Control CS	3
IEE 474 Quality Control CS	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	4
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

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
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

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

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.



Mill Avenue, a short walk from campus, offers students a break from studies with restaurants, movie theatres, and unique shops. The Brickyard building is home to many of the Ira. A. Fulton School of Engineering offices. Tim Trumble photo

TYPICAL FOUR-YEAR SEQUENCE

The first two years are usually devoted to the General Studies and engineering core requirements. A typical schedule is given below.

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

First Year

First Semester

CHM 114 General Chemistry for Engineers <i>SQ</i>	4
or CHM 116 General Chemistry <i>SQ</i> (4)	
ECE 100 Introduction to Engineering Design <i>CS</i>	3
or HU/SB elective ¹ (3)	
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
HU/SB and awareness area course ¹	3
Total	17

Second Semester

ENG 102 First-Year Composition.....	3
-------------------------------------	---

MAT 242 Elementary Linear Algebra.....	2
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ²	3
PHY 122 University Physics Laboratory I <i>SQ</i> ²	1
HU/SB and awareness area course ¹	3
or ECE 100 Introduction to Engineering Design <i>CS</i> (3)	
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>MA</i>	4
MAT 274 Elementary Differential Equations <i>MA</i>	3
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ³	3
PHY 132 University Physics Laboratory II <i>SQ</i> ³	1
Total	17

Second Semester

ECE 201 Electrical Networks I.....	4
ECE 212 Engineering Mechanics II: Dynamics.....	3
ECE 313 Introduction to Deformable Solids.....	3
ECE 340 Thermodynamics.....	3
ECE 384 Numerical Methods for Engineers.....	4
Total	17

Third Year

First Semester

ECE 300 Intermediate Engineering Design <i>L</i>	3
MAE 317 Dynamic Systems and Control.....	3
MAE 319 Measurements and Data Analysis.....	3
MAE 371 Fluid Mechanics.....	3
MAE 422 Mechanics of Materials.....	4
Total	16

Second Semester

MAE 388 Heat Transfer.....	3
MAE 441 Principles of Design.....	3
HU/SB and awareness area courses ¹	3
Technical elective.....	6
Total	15

Fourth Year

First Semester

MAE 491 Experimental Mechanical Engineering.....	3
PHY 361 Introductory Modern Physics.....	3
HU/SB and awareness area course ¹	3
Technical electives.....	6
Total	15

Second Semester

MAE 443 Engineering Design.....	3
MAE 490 Projects in Design and Development <i>L</i>	3
HU/SB and awareness area course ¹	3
Technical electives.....	6
Total	15

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

² Both PHY 121 and 122 must be taken to secure SQ credit.

³ Both PHY 131 and 132 must be taken to secure SQ credit.

MECHANICAL AND AEROSPACE ENGINEERING (MAE)

MAE 101 Introduction to Aerospace Engineering. (2)

fall

Careers in aerospace engineering, problem solving, computer usage in aerospace engineering, contemporary issues of the aerospace industry, the aerospace engineering curriculum. Prerequisites: high school physics and algebra. Pre- or corequisite: ECE 100.

MAE 317 Dynamic Systems and Control. (3)

fall and spring

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 212. Pre- or corequisite: ECE 384.

MAE 319 Measurements and Data Analysis. (3)

fall and spring

Theory of measurement systems, sensors, digital data acquisition, signal processing and statistical analysis. Computer simulations and real-time experiments designed to illustrate these topics. Lecture, lab. Fee. Prerequisite: ECE 201. Pre- or corequisite: MAE 317.

MAE 341 Mechanism Analysis and Design. (3)

once a year

Positions, velocities, and accelerations of machine parts; cams, gears, flexible connectors, and rolling contact; introduces synthesis. Prerequisite: ECE 212.

MAE 351 Manufacturing Processes. (3)

fall and spring

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. Fee. Prerequisite: ECE 350.

MAE 361 Aerodynamics I. (3)

fall

Fluid statics, conservation principles, stream function, velocity potential, vorticity, inviscid flow, Kutta-Joukowski, thin-airfoil theory, and panel methods. Prerequisites: ECE 212, 340.

MAE 371 Fluid Mechanics. (3)

fall and spring

Introductory concepts of fluid motions; fluid statics; control volume forms of basic principles; viscous internal flows. Prerequisites: ECE 212, 340.

MAE 372 Fluid Mechanics. (3)

once a year

Applies basic principles of fluid mechanics to problems in viscous and compressible flow. Prerequisites: ECE 384; MAE 361 (or 371).

MAE 382 Thermodynamics. (3)

once a year

Applied thermodynamics; gas mixtures, psychrometrics, property relationships, power and refrigeration cycles, and reactive systems. Prerequisite: ECE 340.

MAE 388 Heat Transfer. (3)

fall and spring

Steady and unsteady heat conduction, including numerical solutions; thermal boundary layer concepts and applications to free and forced convection. Thermal radiation concepts. Prerequisites: ECE 384; MAE 361 (or 371).

MAE 404 Finite Elements in Engineering. (3)

once a year

Introduces 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)

once a year

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. Fee. Prerequisites: ECE 384; MAE 422, 441 (or 444).

MAE 413 Aircraft Performance, Stability, and Control. (3)

spring

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)

fall

Free and forced response of single and multiple degree of freedom systems, continuous systems; applications in mechanical and aerospace systems numerical methods. Lecture, lab. Fee. Prerequisites: ECE 212; MAE 319, 422 (or 425); MAT 242 (or 342).

MAE 417 Control System Design. (3)

once a year

Tools and methods of control system design and compensation, including simulation, response optimization, frequency domain techniques, state variable feedback, and sensitivity analysis. Introduces nonlinear and discrete time systems. Prerequisite: MAE 317.

MAE 422 Mechanics of Materials. (4)

fall and spring

Theory of stress and strain, generalized Hooke's Law, plasticity, energy methods, finite elements, stress concentrations, fracture and fatigue. Lecture, lab. Fee. Prerequisites: ECE 313; MAT 242 (or 342). Pre- or corequisite: ECE 384.

MAE 425 Aerospace Structures. (4)

fall

Stability, energy methods, finite element methods, torsion, unsymmetrical bending and torsion of multicelled structures, design of aerospace structures. Lecture, lab. Fee. Prerequisites: ECE 313; MAT 242 (or 342).

MAE 426 Design of Aerospace Structures. (3)

once a year

Flight vehicle loads, design of semimonocoque structures, local buckling and crippling, fatigue, aerospace materials, composites, joints, and finite element applications. Prerequisite: MAE 422 or 425.

MAE 433 Air Conditioning and Refrigeration. (3)

once a year

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)

once a year

Performance characteristics, combustion, carburetion and fuel-injection, and the cooling and control of internal combustion engines. Computer modeling. Lab. Fee. Prerequisite: MAE 388.

MAE 435 Turbomachinery. (3)

once a year

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)

once a year

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)

fall and spring

Conceptual and embodiment design of mechanical elements; form synthesis; material selection, failure modes, manufacturability tolerances, common mechanisms, and machine elements. Lecture, lab (project). Fee. Prerequisites: ECE 300, 350. Pre- or corequisites: MAE 319, 422 (or 425).

MAE 442 Mechanical Systems Design. (4)

spring

Applies design principles and techniques to the synthesis, modeling, and optimization of mechanical, electromechanical, and hydraulic systems. Lecture, lab. Fee. Prerequisites: MAE 317, 441 (or 444).

L literacy and critical inquiry / MA mathematics / CS computer/statistics/ quantitative applications / HU humanities and fine arts / SB social and behavioral sciences / SG natural science—general core courses / SQ natural science—quantitative / C cultural diversity in the United States / G global / H historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

MAE 443 Engineering Design. (3)

fall and spring

Group projects to design engineering components and systems. Problem definition ideation, modeling, and analysis; emphasizes decision making and documentation activities. 6 hours lab. Fee. Prerequisite: MAE 441.

MAE 444 Fundamentals of Aerospace Design. (3)

spring

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. Fee. Prerequisites: ECE 300, 350; MAE 361, 425. Pre- or corequisite: MAE 413.

MAE 446 Thermal Systems Design. (3)

once a year

Applies engineering principles and techniques to the modeling and analysis of thermal systems and components. Presents and demonstrates optimization techniques and their use. Prerequisite: ECE 300; MAE 388.

MAE 447 Robotics and Its Influence on Design. (3)

once a year

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)

fall

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. Prerequisites: ECE 313, 350.

MAE 460 Gas Dynamics. (3)

spring

Compressible flow at subsonic and supersonic speeds; duct flow; normal and oblique shocks, perturbation theory, and wind tunnel design. Prerequisites: ECE 384; MAE 361 (or 371).

MAE 461 Aerodynamics II. (3)

once a year

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)

fall

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)

fall

Fundamentals of gas-turbine engines and design of components. Principles and design of rocket propulsion and alternative devices. Lecture, design projects. Prerequisites: ECE 384; MAE 382 (or 460).

MAE 464 Aerospace Laboratory. (3)

fall

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. Fee. Prerequisites: ECE 384; MAE 319, 460.

MAE 465 Rocket Propulsion. (3)

once a year

Rocket flight performance; nozzle design; combustion of liquid and solid propellants; component design; advanced propulsion systems; interplanetary missions; testing. Prerequisite: MAE 382 or 460.

MAE 466 Rotary Wing Aerodynamics and Performance. (3)

once a year

Introduces helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressibility effects. Prerequisites: both ECE 384 and MAE 361 or only instructor approval.

MAE 467 Aircraft Performance. (3)

once a year

Integrates 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 444.

MAE 468 Aerospace Systems Design. (3)

fall and spring

Group projects related to aerospace vehicle design, working from mission definition and continuing through preliminary design. Fee. Prerequisites: MAE 413, 444. Pre- or corequisite: MAE 463.

General Studies: L

MAE 469 Projects in Astronautics or Aeronautics. (3)

fall and spring

Various multidisciplinary team projects available each semester. Projects include design of high-speed rotocraft autonomous vehicles, liquid-fueled rockets, microaerial vehicles, satellites. Fee. Prerequisite: instructor approval.

MAE 471 Computational Fluid Dynamics. (3)

once a year

Numerical solutions for selected problems in fluid mechanics. Fee. Prerequisites: ECE 384; MAE 361 (or 371).

MAE 490 Projects in Design and Development. (3)

fall and spring

Capstone projects in fundamental or applied aspects of engineering. Fee. Prerequisite: MAE 441. Pre- or corequisite: MAE 491.

General Studies: L

MAE 491 Experimental Mechanical Engineering. (3)

fall and spring

Experimental and analytical studies of phenomena and performance of fluid flow, heat transfer, thermodynamics, refrigeration, and mechanical power systems. 6 hours lab. Fee. Prerequisites: MAE 319, 388.

MAE 492 Honors Directed Study. (1–6)

selected semesters

MAE 493 Honors Thesis. (1–6)

selected semesters

MAE 498 Pro-Seminar. (1–3)

selected semesters

Special topics for advanced students. Applies the engineering disciplines to design and analysis of modern technical devices and systems. Prerequisite: instructor approval.

MAE 499 Individualized Instruction. (1–3)

selected semesters

Omnibus Courses. For an explanation of courses offered but not specifically listed in this catalog, see "Omnibus Courses," page 63.

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/aad/catalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see "Graduate-Level Courses," page 62.

Programs in Engineering Special Studies

480/965-1726

Ronald J. Roedel, Director

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.

PROGRAMS IN ENGINEERING SPECIAL STUDIES

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 recent decades, the interrelation between engineering and medicine has become vigorous and exciting. 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 concentration is of special interest to students who desire entry into a medical college and who have medical interests 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. This program is administered by the faculty of the Harrington Department of Bioengineering.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Engineering Special Studies with a concentration in Premedical Engineering. A minimum of 50 upper-division hours is required. Students must attain a GPA of at least 2.00 for the courses in the major field.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See "University Graduation Requirements," page 87.

Note: To fulfill medical school admission requirements, BIO 187 General Biology is required in addition to the degree requirements and is best taken in summer session before the Medical College Admission Test.

COURSE REQUIREMENTS

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 below6

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)

Total6

* A minimum grade of "C" (2.00) is required.

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles *SB*¹3

or ECN 112 Microeconomic Principles *SB*¹ (3)

HU/SB and awareness area courses²12

Total15

Literacy and Critical Inquiry

BME 413 Biomedical Instrumentation *L*³3

BME 423 Biomedical Instrumentation Laboratory *L*³1

ECE 300 Intermediate Engineering Design *L*3

Total7

Natural Sciences

PHY 121 University Physics I: Mechanics *SQ*⁴3

PHY 122 University Physics Laboratory I *SQ*⁴1

PHY 131 University Physics II: Electricity and Magnetism *SQ*⁵3

PHY 132 University Physics Laboratory II *SQ*⁵1

Total8

Mathematical Studies

ECE 100 Introduction to Engineering Design *CS*3

ECE 384 Numerical Methods for Engineers4

MAT 270 Calculus with Analytic Geometry I *MA*4

MAT 271 Calculus with Analytic Geometry II *MA*4

MAT 272 Calculus with Analytic Geometry III *MA*4

MAT 274 Elementary Differential Equations *MA*3

Total22

General Studies/school requirements total52

Engineering Core

ECE 201 Electrical Networks I4

ECE 214 Engineering Mechanics4

ECE 334 Electronic Circuits4

ECE 340 Thermodynamics3

ECE 350 Structure and Properties of Materials3

Total18

Engineering Special Studies Program Major—Premedical Engineering Concentration

BIO 188 General Biology II *SQ*4

BME 101 Introduction to Bioengineering3

BME 235 Physiology for Engineers4

BME 318 Biomaterials3

BME 331 Biomedical Engineering Transport: Fluids3

BME 350 Signals and Systems for Bioengineers3

BME 417 Biomedical Engineering Capstone Design I3

BME 470 Microcomputer Applications in Bioengineering4

BME 490 Biomedical Engineering Capstone Design II3

CHM 113 General Chemistry *SQ*4

CHM 116 General Chemistry *SQ*4

CHM 331 General Organic Chemistry3

CHM 332 General Organic Chemistry3

CHM 335 General Organic Chemistry Laboratory1

L literacy and critical inquiry / *MA* mathematics / *CS* computer/statistics/quantitative applications / *HU* humanities and fine arts / *SB* social and behavioral sciences / *SG* natural science—general core courses / *SQ* natural science—quantitative / *C* cultural diversity in the United States / *G* global / *H* historical / See "General Studies," page 91.

IRA A. FULTON SCHOOL OF ENGINEERING

CHM 336 General Organic Chemistry Laboratory.....	1
CSE 100 Principles of Programming with C++ <i>CS</i> ⁶	3
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
Total	52

- ¹ ECN 111 or 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 BME 413 and 423 must be taken to secure L credit.
- ⁴ Both PHY 121 and 122 must be taken to secure SQ credit.
- ⁵ Both PHY 131 and 132 must be taken to secure SQ credit.
- ⁶ CSE 110 Principles of Programming with Java can be substituted for CSE 100 with departmental approval.

Premedical Engineering Program of Study Typical Four-Year Sequence

First Year

First Semester

CSE 100 Principles of Programming with C++ <i>CS</i> ¹	3
ECE 100 Introduction to Engineering Design <i>CS</i>	3
ENG 101 First-Year Composition.....	3
MAT 270 Calculus with Analytic Geometry I <i>MA</i>	4
Total	13

Second Semester

BME 101 Introduction to Bioengineering.....	3
CHM 113 General Chemistry <i>SQ</i>	4
ENG 102 First-Year Composition.....	3
MAT 271 Calculus with Analytic Geometry II <i>MA</i>	4
PHY 121 University Physics I: Mechanics <i>SQ</i> ²	3
PHY 122 University Physics Laboratory I <i>SQ</i> ²	1
Total	18

Second Year

First Semester

BIO 188 General Biology II <i>SQ</i>	4
CHM 116 General Chemistry <i>SQ</i>	4
MAT 272 Calculus with Analytic Geometry III <i>MA</i>	4
PHY 131 University Physics II: Electricity and Magnetism <i>SQ</i> ³	3
PHY 132 University Physics Laboratory II <i>SQ</i> ³	1
Total	16

Second Semester

BME 235 Physiology for Engineers.....	4
ECE 201 Electrical Networks I.....	4

ECE 350 Structure and Properties of Materials	3
ECN 111 Macroeconomic Principles <i>SB</i>	3
or ECN 112 Microeconomic Principles <i>SB</i> (3)	
MAT 274 Elementary Differential Equations <i>MA</i>	3
Total	17

Third Year

First Semester

BME 318 Biomaterials	3
CHM 331 General Organic Chemistry	3
CHM 335 General Organic Chemistry Laboratory.....	1
ECE 214 Engineering Mechanics.....	4
ECE 300 Intermediate Engineering Design <i>L</i>	3
ECE 384 Numerical Methods for Engineers.....	4
Total	18

Second Semester

BME 331 Biomedical Engineering Transport: Fluids	3
BME 350 Signals and Systems for Bioengineers.....	3
CHM 332 General Organic Chemistry	3
CHM 336 General Organic Chemistry Laboratory.....	1
ECE 334 Electronic Circuits	4
ECE 340 Thermodynamics.....	3
Total	17

Fourth Year

First Semester

BME 413 Biomedical Instrumentation <i>L</i> ⁴	3
BME 417 Biomedical Engineering Capstone Design I.....	3
BME 423 Biomedical Instrumentation Laboratory <i>L</i> ⁴	1
ECE 380 Probability and Statistics for Engineering Problem Solving <i>CS</i>	3
HU/SB and awareness area courses ⁵	6
Total	16

Second Semester

BME 470 Microcomputer Applications in Bioengineering.....	4
BME 490 Biomedical Engineering Capstone Design II.....	3
HU/SB and awareness area course ⁵	6
Total	13
Total degree requirements.....	128

- ¹ CSE 110 Principles of Programming with Java can be substituted for CSE 100 with departmental approval.
- ² Both PHY 121 and 122 must be taken to secure SQ credit.
- ³ Both PHY 131 and 132 must be taken to secure SQ credit.
- ⁴ Both BME 413 and 423 must be taken to secure L credit.
- ⁵ Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements.