PURPOSE

The Ira A. Fulton School of Engineering educates undergraduate and graduate engineering students, giving them the knowledge, skills, and attitudes they need for success in technically oriented careers. The school provides students with a range of educational opportunities by which they may achieve excellence in the major branches of engineering, in computer science, and in construction management.

The Fulton School takes pride in its diversity, its economic and cultural heritage, and in the quality of its graduates. It strives to be an integral part of the community it serves and a lifelong presence in the lives of those within its compass. The school’s educational and research programs are built around the following principles: entrepreneurship; use-inspired research and scholarship; a focus on the individual; intellectual fusion of unique and distinct disciplines; social embeddedness in the local, national, and international community; and global engagement.

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

THE FULTON ASPIRATIONS

Graduates from any of the school’s programs will be technically sound. In addition to technical competency, the Fulton School aspires to develop leaders who are aware of biological issues, well read and well spoken, and knowledgeable about current business practices. To this end the school offers enhanced curricula, special courses, and extracurricular activities to enrich the student’s stay and to offer every student opportunities to achieve the school’s aspirations.

All the programs within the school are professional programs, and hence professionalism is an important component of all the curricula. The school strives to help students understand and value the various aspects of professionalism including ethical behavior; a desire for life long learning; the ability to communicate with others, and an awareness of how the profession fits into and impacts society. As a first step in ethics, all students are expected to follow rules of academic integrity defined by the university.

For more information, access the Web site at www.asu.edu/studentlife/judicial/integrity.html.

ORGANIZATION

The Fulton School of Engineering includes three primary educational components: eight academic units, several research centers, and the Center for Professional Development.

Departments. The school houses eight 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 educational role. The school encourages the participation of qualified undergraduate and graduate students in various research activities. Most faculty are involved in government- or industry-sponsored research programs in a wide variety of fields. This research is carried out in the academic units and in a number of interdisciplinary research institutes, centers, and programs. A list of centers is available on the Web at www.fulton.asu.edu/fulton/research/centers.php.

Center for Professional Development. The Center for Professional Development (CPD) provides engineers and technical professionals the skills and knowledge necessary to master new methods, to lead projects and teams, and to advance professionally. Programs are offered in traditional classroom environments and through distance learning. CPD works with the nationally renowned faculty of the Fulton School of Engineering and affiliate experts to administer short courses and conferences, professional certifica-
ADMISSION

The technical programs housed in the school are demanding, and success requires good preparation. High school students are expected to have completed a college preparation curriculum including math through precalculus; transfer students are expected to have performed well in their postsecondary work. Students who are not well prepared may be required to enroll in university courses that are not applicable for degree credit. High school students interested in degrees within the school are encouraged to consult an advisor to help ensure that a proper set of high school and/or postsecondary courses are being taken.

Students eligible for admission to one of the school programs are admitted to either preprofessional or professional status in the program of interest. The processes and standards used to admit students depend on whether the students are first-time freshmen, transfer students from outside of ASU, transfer students from within ASU, or readmission students.

Preprofessional and Professional Status. Students who have a high likelihood of success are admitted with professional status; other students are admitted with preprofessional status. The difference is that preprofessional students are permitted to register for only lower-division (100- and 200-level) classes within the school.

Promotion to professional status is done in one of two ways. Students in the Computer Science or Computer Systems Engineering programs use one method; for more information, see “Department of Computer Science and Engineering,” page 249, or access the Web site at www.eas.asu.edu/~csedep/AcademicPrograms/Undergraduate/UGPrograms.htm. Promotion for all other students is a two-step process:

1. In consultation with an academic advisor, lower division courses are selected.
2. After completing a minimum of 30 semester hours of required or approved elective course work with a cumulative GPA equivalent to that required of transfer students and corresponding to the chosen major, students may apply for promotion to professional status (see the “Professional Status Requirements” table, on this page). Note: For transfer students, the cumulative GPA includes the transfer GPA.

Admission as First-Time Freshmen. Students other than those interested in Computer Science or Computer Systems Engineering who meet one of the requirements listed in the “Professional Status Requirements” table are admitted to programs within the school with professional status. Students who are not admissible to professional status within the school but are otherwise regularly admissible to ASU are admitted to one of the school’s programs with preprofessional status.

All students interested in Computer Science or Computer Systems Engineering, who meet the university admission requirements as stated in “Office of Undergraduate Admissions,” page 65, are admitted with preprofessional status.

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 on the paper version (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.

Admission of Transfer Students. As with freshmen, admission of Computer Science and Computer Systems Engineering (CS and CSE) transfer students is different.

1. All non-CS and CSE transfer students who meet the requirements shown in the “Professional Status Requirements” table are admitted with professional status.
2. All non-CS and CSE transfer students who are not admissible to professional status within the school but are otherwise regularly admissible to ASU are...
admitted to one of the school’s programs with preprofessional status.

3. All CS and CSE transfer students who meet the university admission standards, as stated in “Office of Undergraduate Admissions,” page 65, are admitted with preprofessional status.

The academic units may impose additional admission and graduation requirements beyond the minimum specified by the school.

Change of Major Within ASU. Students moving between academic programs within the school or from other colleges or schools within the university are admitted under the same conditions as transfer students.

Readmission. Students reapplying to the school after a one semester absence must meet the following requirements to be considered for readmission: Engineering students are required to have 2.50 or higher cumulative GPA for all courses completed; in-state Construction students must have a 2.25 cumulative GPA for all courses completed. Students with lower GPAs may be denied readmission. Preprofessional students with less than the 2.50 GPA for all courses will be denied readmission.

Computer Science and Computer Systems Engineering students will be readmitted as preprofessionals provided they meet the readmission requirements for engineering students. Students should consult the Computer Science advising office at 480/965-3199 for readmission information to their professional status.

Students seeking readmission should contact the Office of the Associate Dean of Academic Affairs.

Evaluation of Previous Course Work. Transferring from one institution to another or between programs can result in a net loss in units that count toward the degree. Thus it is important for students who contemplate transferring into this school from another institution, whether a community college or four-year institution, to carefully study the catalog material pertaining to the particular program to get a sense of what courses may transfer.

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 students 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.

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.

ADVISING

Each department in the Fulton School employs one or more professional academic advisors to work with students in setting academic and career goals; understanding school and university policies and procedures; meeting degree requirements; and becoming familiar with the university’s and school’s sources of academic support and success. Students may also work with a faculty advisor familiar with the chosen field of specialization. While final responsibility for becoming familiar with and understanding academic degree requirements lies with the student, professional and faculty advisors are available to assist. Students should consult with an advisor before registering each semester.

Many students find it necessary to work while attending ASU. The working student should endeavor to create a careful balance of work and class responsibilities to avoid academic problems. Students should inform faculty and professional advisors of any outside work or activity so that course loads may be adjusted accordingly.

The Office of the Associate Dean for Academic Affairs in the school is available to assist individual students with many different types of advising issues. Advisors and staff work with students to answer general questions regarding policy and procedure; help with registration transactions; administer the probation, disqualification, and readmission processes; oversee disciplinary actions; and hear grade grievances and assist with other administrative matters. More information is available from the school Web site.

REGISTRATION

Students are required to register for courses using one of the university-provided processes. As part of the registration process, the school enforces the following registration restrictions.

Mandatory Advising. All first-year students, all student athletes, and students who are found to be having academic difficulty are required to be advised before they can register for classes, including summer sessions. Some programs relax the advisement requirement after the first year, so students should consult their department to determine if advising is required.

Maximum Hours. 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.

Probationary Status. Students who have been placed on academic probation must be advised by a faculty or professional advisor from within the academic unit of their major and then advised by an advisor within the Office of the Associate Dean of Academic Affairs, who will issue a
special permit allowing them to register. Students on probation are limited to 13 semester hours. The special permits are not issued until after grades have been posted.

**Undergraduate Nondegree Status.** 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 Office of the Associate Dean of Academic Affairs. For more information, see “Admission of Undergraduate Nondegree Applicants,” page 72.

**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, or the dean of the college. In such cases, students will not receive monetary reimbursement.

**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 Office of Undergraduate Nondegree Applicants. Each request is judged on its particular merits.

**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.

**UNDERGRADUATE DEGREES**

The faculty in the Fulton School of Engineering offer programs leading to the BS and BSE degrees with majors in the subjects shown in the “Ira A. Fulton School of Engineering Baccalaureate Degrees and Majors” table, page 218. Each major is administered by the academic unit indicated. 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.

**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, page 219. Engineering faculty participate in offering the Master of Engineering (MEng) as a collaborative degree program offered by Arizona’s three state universities. For more information, see the Graduate Catalog.

**COLLEGE OF EXTENDED EDUCATION**

The university-wide College of Extended Education provides an interactive link between ASU and the diverse communities it serves. The college assesses lifelong learning requirements and works in partnership with campuses, other colleges, and the community to serve learners, using a network of locations, programs, schedules, and technologies.

For more information, see “College of Extended Education,” page 703, or access the Web site at www.asu.edu/ced.

**UNIVERSITY GRADUATION REQUIREMENTS**

In addition to department and school requirements, students must meet all university graduation requirements (see “University Graduation Requirements,” page 88). 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 88. 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.

**STUDENT RESPONSIBILITIES**

Students have to make many decisions as they complete their degrees. While the school and the university make a number of resources available (e.g., faculty, courses, advisors, and tutors) to help in making the decisions, students are expected to take responsibility for making them.
Students are expected to select and successfully complete courses that lead to the timely completion of their degree. Students are said to be making satisfactory progress if they (1) maintain an acceptable GPA and (2) complete courses each semester that are applicable to their degree. Students who are making satisfactory progress are said to be in good standing.

**PROBATION**

Some students do not make satisfactory progress, and these students generally need extra attention and resources to help them get back on track. Such students are placed on probation to help track them and ensure they get the necessary help. Students on probation have their course load constrained. These students may also be required to take specific courses to help them gain the skills needed to be successful.

Various conditions can place a student on probation whereas others trigger a review of the student’s case to determine if probation is warranted. When a probation review is triggered, the final decision and conditions of probation are made by the student’s department.

### Automatic Probation

These conditions trigger automatic probation:

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 below 2.00 (for more than 55 semester hours).

### Automatic Review

These conditions trigger probation review:

1. an ASU cumulative GPA less than 2.00 (0 to 55 semester hours);
2. a cumulative GPA in the major of less than 2.00; or

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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.
Ira A. Fulton School of Engineering Graduate Degrees and Majors

<table>
<thead>
<tr>
<th>Major</th>
<th>Degree</th>
<th>Concentration ¹</th>
<th>Administered By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>MS, MSE, PhD —</td>
<td></td>
<td>Department of Mechanical and Aerospace Engineering</td>
</tr>
<tr>
<td>Bioengineering</td>
<td>MS, PhD —</td>
<td></td>
<td>Harrington Department of Bioengineering</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>MS, MSE, PhD —</td>
<td></td>
<td>Department of Chemical and Materials Engineering</td>
</tr>
<tr>
<td>Civil and Environmental</td>
<td>MS, MSE, PhD —</td>
<td></td>
<td>Department of Civil and Environmental Engineering</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science</td>
<td>MCS    —</td>
<td>Optional: arts, media, and engineering ¹</td>
<td>Department of Computer Science and Engineering</td>
</tr>
<tr>
<td></td>
<td>MS, PhD —</td>
<td></td>
<td>Department of Computer Science and Engineering</td>
</tr>
<tr>
<td>Construction</td>
<td>MS      —</td>
<td>Optional: construction science, facilities, or management ¹</td>
<td>Del E. Webb School of Construction</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>MS, PhD, MSE —</td>
<td>Optional: arts, media, and engineering ¹</td>
<td>Department of Electrical Engineering</td>
</tr>
<tr>
<td></td>
<td>MEng   —</td>
<td></td>
<td>Department of Electrical Engineering</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>MS, MSE —</td>
<td>Optional: executive embedded systems ¹</td>
<td>Ira A. Fulton School of Engineering</td>
</tr>
<tr>
<td></td>
<td>PhD    —</td>
<td>Optional: materials science and engineering ¹</td>
<td>Ira A. Fulton School of Engineering</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>MS, MSE, PhD —</td>
<td></td>
<td>Department of Industrial Engineering</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>MS, MSE —</td>
<td></td>
<td>Department of Chemical and Materials Engineering</td>
</tr>
<tr>
<td>Materials Science</td>
<td>MS ²  —</td>
<td></td>
<td>Committee on the Science and Engineering of Materials</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>MS, MSE, PhD —</td>
<td></td>
<td>Department of Mechanical and Aerospace Engineering</td>
</tr>
<tr>
<td>Science and Engineering of</td>
<td>PhD ² —</td>
<td>High-resolution nanostructure analysis or solid-state device materials design</td>
<td>Committee on the Science and Engineering of Materials</td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ If a major offers concentrations, one must be selected unless noted as optional.
² This program is administered by the Division of Graduate Studies.

3. failure to complete any courses appropriate for the degree during each semester.

**Disqualification.** 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 the Office of the Associate Dean for Academic Affairs. Special permits are not given until grades are recorded by the registrar for the current semester.

**Disqualification**

Students who are on academic probation and fail to meet the retention standards become ineligible to continue working toward a degree within the school. These limitations apply:

1. Students who change colleges may not register for courses in engineering unless the courses are required by their new major.
2. Students who register for courses in the school may be withdrawn from these courses any time during the semester they are registered.
3. Students may be eligible to change their major to another college if they have a cumulative GPA of 2.00 or higher.
4. Students may take nonengineering courses during summer and winter sessions.
5. Students who have completed fewer than 25 semester hours with a cumulative GPA of 1.75 or higher may be eligible for study with the University College.
6. Students may request a review of their status by contacting the Office of the Associate Dean for Academic Affairs.

**Reinstatement**
The school does not accept an application for reinstatement until the disqualified student has remained out of the 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.

**SPECIAL PROGRAMS**

**Fulton Scholars.** The Fulton Scholars are a group of highly motivated, talented students who have the opportunity to participate in enriched intellectual, cultural, and social programs during their college years. Membership is competitive and admission is determined at the time of admission to the program. For more information, access the Web site at www.fulton.asu.edu/fulton/students/index.php.

**Fulton Ambassadors.** The Fulton Ambassadors is composed of undergraduate students representing all disciplines within the school. Originally called “Student Ambassadors,” the name was changed in fall 2003 to “Fulton Ambassadors” in recognition of Ira A. Fulton’s contribution to the school of engineering. Fulton Ambassadors promote and advance the school at ASU and serve as student liaisons between current students, administrators, alumni, and industry. For more information, access the Web site at www.fulton.asu.edu/fulton/students/index.php.

**SORP.** The Student Outreach and Retention Program (SORP) houses student diversity programs in the Ira A. Fulton School of Engineering. SORP offers programs and services to improve the climate for, and to attract, support, and retain minority and women students in engineering. Programs included in SORP are the Women in Science and Engineering Program, the Minority Engineering Program, and the Coalition of Engineering Minority Societies and the Society of Women Engineers (CEMSWE).

CEMSWE encourages the minority engineering organizations: American Indian Science and Engineering Society, National Society of Black Engineers, Society of Hispanic Professional Engineers, and the Society of Women Engineers to work together to maximize their effectiveness in many areas.

In addition, SORP houses the Center for Outreach and Recruitment (COR) for the Fulton School. This unit supports the recruitment programs for the Fulton School of Engineering, including the Central Arizona Math, Engineering, Science Achievement program. COR coordinates the Engineering Summer Institute, providing hands-on engineering camps, both commuter and residential, to middle school, high school, and incoming freshmen students. For more information, contact the Office of the Associate Dean of Academic Affairs.

**Joint Bachelor’s and Master’s Degree.** Several programs within the school offer an opportunity to their highly motivated and high-performing students to start a master’s program while still completing the last year of the BSE degree. Interested students should contact their major department for details.

**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 the Office of the Associate Dean for Academic Affairs, 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 129.

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 the Office of the Associate Dean for Academic Affairs or the various department or school offices. Other scholarships may be available through the university Student Financial Assistance Office. For an application and more information, access the Web site at www.fulton.asu.edu/fulton/students/index.php.

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 Department of Military Science. To preclude excessive overloads, these students should plan on at least one additional semester to complete degree requirements. Because of accreditation requirements, aerospace studies (AES) or military science (MIS) courses are not acceptable for degree credit in engineering as social and behavioral science or humanities and fine arts under General Studies. ROTC students must also meet all other degree requirements of this 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, Wiezel

Assistant Professors: Fiori, Knutson, Mitropoulos, Sullivan

Visiting Eminent Scholars: Mathews, 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 the business management of 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—BS

The faculty in the Del E. Webb School of Construction offer the BS 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—MS

The faculty in the school also offer the MS 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 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 66; “Admission,” page 215; and “Degree Requirements,” on this page. A pre-professional 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 88) 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 92, and all university graduation requirements as noted in “University Graduation Requirements,” page 88. 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:

<table>
<thead>
<tr>
<th>Humanities and Fine Arts/Social and Behavioral Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 101 Construction and Culture: A Built Environment</td>
</tr>
<tr>
<td>ECN 111 Macroeconomic Principles SB ..........................3</td>
</tr>
<tr>
<td>ECN 112 Microeconomic Principles SB ..........................3</td>
</tr>
<tr>
<td>HU/SB and awareness area course as needed ..................3</td>
</tr>
<tr>
<td>HU/SB (upper division) and awareness area course as needed ........................................3</td>
</tr>
<tr>
<td>Total ...........................................................................15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literacy and Critical Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM 225 Public Speaking L ..........3</td>
</tr>
<tr>
<td>CON 496 Construction Contract Administration L ........3</td>
</tr>
<tr>
<td>Total .................................................................6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHY 111 General Physics SQ1  .................3</td>
</tr>
<tr>
<td>PHY 112 General Physics SQ2  .................3</td>
</tr>
<tr>
<td>PHY 113 General Physics Laboratory SQ1 ....1</td>
</tr>
<tr>
<td>PHY 114 General Physics Laboratory SQ2 ....1</td>
</tr>
<tr>
<td>Total .................................................................8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mathematical Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I MA ......4</td>
</tr>
<tr>
<td>STP 226 Elements of Statistics CS ................3</td>
</tr>
<tr>
<td>Total .................................................................7</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC 230</td>
<td>Uses of Accounting Information I</td>
</tr>
<tr>
<td>CON 221</td>
<td>Applied Engineering Mechanics: Statics</td>
</tr>
<tr>
<td>CON 223</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>CON 243</td>
<td>Heavy Construction Equipment, Methods, and Materials</td>
</tr>
<tr>
<td>CON 251</td>
<td>Microcomputer Applications for Construction</td>
</tr>
<tr>
<td>CON 273</td>
<td>Electrical Construction Fundamentals</td>
</tr>
<tr>
<td>CON 296</td>
<td>Field Internship</td>
</tr>
<tr>
<td>CON 310</td>
<td>Testing of Materials for Construction</td>
</tr>
<tr>
<td>CON 341</td>
<td>Surveying</td>
</tr>
<tr>
<td>CON 345</td>
<td>Mechanical Systems</td>
</tr>
<tr>
<td>CON 371</td>
<td>Construction Management and Safety</td>
</tr>
<tr>
<td>CON 383</td>
<td>Construction Estimating</td>
</tr>
<tr>
<td>CON 389</td>
<td>Construction Cost Accounting and Control CS</td>
</tr>
<tr>
<td>CON 424</td>
<td>Structural Design</td>
</tr>
<tr>
<td>CON 450</td>
<td>Geotechnical Applications for Construction</td>
</tr>
<tr>
<td>CON 453</td>
<td>Construction Labor Management</td>
</tr>
<tr>
<td>CON 455</td>
<td>Construction Project Management</td>
</tr>
<tr>
<td>CON 484</td>
<td>Managerial Internship</td>
</tr>
<tr>
<td>CON 494</td>
<td>Special Topics</td>
</tr>
<tr>
<td>CON 495</td>
<td>Construction Planning and Scheduling CS</td>
</tr>
<tr>
<td>ECE 100</td>
<td>Introduction to Engineering Design CS</td>
</tr>
<tr>
<td>LES 305</td>
<td>Legal, Ethical, and Regulatory Issues in Business</td>
</tr>
<tr>
<td>or W LES 306 Business Law</td>
<td>3</td>
</tr>
<tr>
<td>or LES 380 Consumer Perspective of Business Law</td>
<td>3</td>
</tr>
<tr>
<td>EIE 305</td>
<td>Construction Management</td>
</tr>
<tr>
<td>MGMT 301</td>
<td>Management of Projects</td>
</tr>
<tr>
<td>or MGMT 302</td>
<td></td>
</tr>
<tr>
<td>Physical science elective with lab</td>
<td>4</td>
</tr>
<tr>
<td>Total common to all concentrations</td>
<td>71</td>
</tr>
</tbody>
</table>

\* 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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 101</td>
<td>Construction and Culture: A Built Environment</td>
</tr>
<tr>
<td>ECN 111</td>
<td>Macroeconomic Principles (SB)</td>
</tr>
<tr>
<td>ENG 101</td>
<td>First-Year Composition</td>
</tr>
<tr>
<td>MAT 270</td>
<td>Calculus with Analytic Geometry (IMA)</td>
</tr>
<tr>
<td>PHY 111</td>
<td>General Physics (SQ^1)</td>
</tr>
<tr>
<td>PHY 113</td>
<td>General Physics Laboratory (SQ^1)</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
</tr>
</tbody>
</table>

Second Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 100</td>
<td>Introduction to Engineering Design CS</td>
</tr>
</tbody>
</table>

ECN 112 Microeconomic Principles \(SB\) | 3 |
ENG 102 First-Year Composition | 3 |
PHY 112 General Physics \(SQ^2\) | 3 |
PHY 114 General Physics Laboratory \(SQ^2\) | 1 |
H U elective with awareness area as needed | 3 |
Total | 16 |

Third Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 221</td>
<td>Applied Engineering Mechanics: Statics</td>
</tr>
<tr>
<td>CON 243</td>
<td>Heavy Construction Equipment, Methods, and Materials</td>
</tr>
<tr>
<td>CON 251</td>
<td>Microcomputer Applications for Construction</td>
</tr>
<tr>
<td>CON 273</td>
<td>Electrical Construction Fundamentals</td>
</tr>
<tr>
<td>STP 226</td>
<td>Elements of Statistics CS</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
</tr>
</tbody>
</table>

Fourth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC 230</td>
<td>Uses of Accounting Information I</td>
</tr>
<tr>
<td>or ACC 394 ST: Financial Analysis and Accounting for Small Businesses</td>
<td>3</td>
</tr>
<tr>
<td>COM 225</td>
<td>Public Speaking</td>
</tr>
<tr>
<td>CON 223</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>CON 252</td>
<td>Building Construction Methods, Materials, and Equipment</td>
</tr>
<tr>
<td>Physical science elective with lab</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>

\(^1\) 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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 472</td>
<td>Development Feasibility Reports (L)</td>
</tr>
<tr>
<td>CON 483</td>
<td>Advanced Building Estimating</td>
</tr>
<tr>
<td>PUP 432</td>
<td>Planning and Development Control Law</td>
</tr>
<tr>
<td>or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes</td>
<td>3</td>
</tr>
<tr>
<td>REA 380</td>
<td>Real Estate Fundamentals</td>
</tr>
<tr>
<td>Upper-division elective</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
</tr>
</tbody>
</table>

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 earthwork.

**Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 486 Heavy Construction Estimating</td>
<td>3</td>
</tr>
<tr>
<td>CON 494 ST: Heavy Construction Project Management</td>
<td>3</td>
</tr>
<tr>
<td>Upper-division electives</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 377 Residential Construction Production Procedures</td>
<td>3</td>
</tr>
<tr>
<td>CON 477 Residential Construction Business Practices</td>
<td>3</td>
</tr>
<tr>
<td>MKT 382 Advertising and Marketing Communication</td>
<td>3</td>
</tr>
<tr>
<td>PUP 432 Planning and Development Control Law</td>
<td>3</td>
</tr>
<tr>
<td>or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes</td>
<td>3</td>
</tr>
<tr>
<td>Upper-division elective</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 468 Mechanical and Electrical Estimating</td>
<td>3</td>
</tr>
<tr>
<td>CON 471 Mechanical and Electrical Project Management</td>
<td>3</td>
</tr>
<tr>
<td>CON 494 ST: Cleanroom Construction</td>
<td>3</td>
</tr>
<tr>
<td>Upper-division electives</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

**Construction (CON)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON 101 Construction and Culture: A Built Environment</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>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</td>
<td></td>
</tr>
<tr>
<td>CON 221 Applied Engineering Mechanics: Statics</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>CON 223 Strength of Materials</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Analyzes strength and rigidity of structural members in resisting applied forces. Stress, strain, shear, moment, deflections, combined stresses, and connections. Both U.S. and SI units of measurement. Prerequisite: CON 221.</td>
<td></td>
</tr>
<tr>
<td>CON 243 Heavy Construction Equipment, Methods, and Materials</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Emphasizes “Horizontal” construction. Fleet operations, maintenance programs, methods, and procedures to construct tunnels, roads, dams, and the excavation of buildings. Lab, field trips. Fee.</td>
<td></td>
</tr>
<tr>
<td>CON 251 Microcomputer Applications for Construction</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Applies the microcomputer as a problem-solving tool for the constructor. Uses spreadsheets, information management, and multimedia software. Prerequisite: ECE 100.</td>
<td></td>
</tr>
<tr>
<td>CON 252 Building Construction Methods, Materials, and Equipment</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Emphasizes “Vertical” construction. Methods, materials, codes, and equipment used in building construction corresponding to the 16 division “Master Format.”</td>
<td></td>
</tr>
<tr>
<td>CON 273 Electrical Construction Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Lecture, field trips. Prerequisites: PHY 112, 114.</td>
<td></td>
</tr>
<tr>
<td>CON 296 Field Internship</td>
<td>1</td>
</tr>
<tr>
<td>summer</td>
<td></td>
</tr>
<tr>
<td>Participation as interns on construction projects to observe and experience the daily activities. Internship. Fee.</td>
<td></td>
</tr>
<tr>
<td>CON 310 Testing of Materials for Construction</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Structural and behavioral characteristics, engineering properties, measurements, and application of construction materials. Not open to engineering students. Lecture, lab. Fee. Prerequisite: CON 223.</td>
<td></td>
</tr>
<tr>
<td>CON 341 Surveying</td>
<td>3</td>
</tr>
<tr>
<td>fall, spring, summer</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>CON 345 Mechanical Systems</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>CON 371 Construction Management and Safety</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Organization and management theory applied to the construction process. Leadership functions. Safety procedures and equipment. OSHA requirements for construction. Prerequisite: CON 292.</td>
<td></td>
</tr>
<tr>
<td>CON 377 Residential Construction Production Procedures</td>
<td>3</td>
</tr>
<tr>
<td>spring</td>
<td></td>
</tr>
<tr>
<td>Process used in residential construction. How a house is built: design, permits, scheduling, codes, contracting, site management, mechanical/electrical. Prerequisite: CON 252.</td>
<td></td>
</tr>
<tr>
<td>CON 383 Construction Estimating</td>
<td>4</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>CON 389 Construction Cost Accounting and Control</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>CON 424 Structural Design</td>
<td>3</td>
</tr>
<tr>
<td>fall</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>CON 450 Geotechnical Applications for Construction</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>Soil formation, engineering properties and use as building materials. Soil’s influence on construction of built environment, including specifications. Lecture, lab, site visits. Fee. Prerequisite: CON 310.</td>
<td></td>
</tr>
<tr>
<td>CON 453 Construction Labor Management</td>
<td>3</td>
</tr>
<tr>
<td>fall and spring</td>
<td></td>
</tr>
<tr>
<td>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. Prerequisites: CON 371; ECN 112.</td>
<td></td>
</tr>
</tbody>
</table>
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, CPE exam. Fee. Prerequisite: CON 371. Pre- or corequisite: CON 495.

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

CON 471 Mechanical and Electrical Project Management. (3)  
*spring*  
Syerollies 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.

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, lifecycle 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. (1)  
  Fee. 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*  
- Heavy Construction Project Management. (3)

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.

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: CON 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.
IRA A. FULTON SCHOOL OF ENGINEERING

DEGREES

The Bachelor of Science in Engineering (BSE) degree consists of three parts:

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

The BS 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 92). There are also requirements for historical awareness, global awareness, and cultural diversity in the United States. ABET imposes additional requirements, particularly in mathematics, 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 major courses in the 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 varies 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, page 227, 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 SQ.............. 4 or 8
or CHM 113 General Chemistry SQ (4)
and CHM 116 General Chemistry SQ (4)
ECE 100 Introduction to Engineering Design SQ.................. 3
ECN 111 Macroeconomic Principles SB........................... 3
or ECN 112 Microeconomic Principles SB (3)
ENG 101 First-Year Composition...................................... 3
ENG 102 First-Year Composition...................................... 3
MAT 270 Calculus with Analytic Geometry I MA.............. 4
MAT 271 Calculus with Analytic Geometry II MA ............ 4
PHY 121 University Physics I: Mechanics SQ*................. 3
PHY 122 University Physics Laboratory I SQ*................. 1
HU/SB and awareness area course...................................... 3

Total ..................................................................................... 31 or 35

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

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 88), and the literacy and critical inquiry component (see “Five Core Areas,” page 92) 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 BS and BSE degrees follow.

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

**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 and awareness area courses .................................................. 6 or 9
- SB and awareness area course(s) ............................................. 3 or 6
- Total ............................................................................................... 15

**Literacy and Critical Inquiry**
- ECE 300 Intermediate Engineering Design L .......................... 3
- ECE 400 Engineering Communications L ............................... 5
- Total ............................................................................................... 6

**Mathematical, Computation, and Quantitative Studies**
- ECE 100 Introduction to Engineering Design CS .............. 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 274 Elementary Differential Equations MA .............. 3
- Department mathematics elective ........................................... 2
- Total ............................................................................................... 20

**Natural Sciences/Basic Sciences**
- CHM 114 General Chemistry for Engineers SQ .............. 4
- or CHM 116 General Chemistry SQ (4)
- PHY 121 University Physics I: Mechanics SQ .............. 3
- PHY 122 University Physics Laboratory I SQ .............. 1
- PHY 131 University Physics II: Electricity and Magnetism SQ .......................... 3
- PHY 132 University Physics Laboratory II SQ .............. 1
- Department basic science elective ........................................... 3
- Total ............................................................................................... 15
- General Studies/school requirements total ......................... 56

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1 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to obtain 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 .................................................. 4
- ECE 210 Engineering Mechanics I: Statics ........................... 3
- ECE 212 Engineering Mechanics II: Dynamics ................... 3
- ECE 214 Engineering Mechanics ........................................... 4
- ECE 313 Introduction to Deformable Solids ....................... 3
- ECE 334 Electronic Circuits .................................................. 4
- Choose one thermodynamics course below ........................ 3 or 4
- ECE 340 Thermodynamics (3)
- CHE 342 Introduction to Applied Chemical Thermodynamics (4)
- MSE 430 Thermodynamics of Materials (3)
- Choose one materials course below ................................. 3 or 4
- ECE 350 Structure and Properties of Materials (3)
- ECE 351 Civil Engineering Materials (3)
- ECE 352 Properties of Electronic Materials (3)
- 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)

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**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 BS program in Computer Science is accredited by the Computer Science Accreditation Commission of ABET.

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**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 PROGRAMS

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).

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.

ECE 201 Electrical Networks I. (4)
fall and spring
Fundamental network theorems for dc and ac analysis. Utilization of SPICE. Design and measurement of linear analog electrical systems. Lecture, lab. Fee. Prerequisites: ECE 100 (or 200); 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. Team skills enhanced. Fee. Prerequisites: ECE 100 (or 200); ENG 102 (or 105 or 108); at least two other engineering core courses.

ECE 301 Dynamics. (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 350 Structure and Properties of Materials. (3)
fall, spring, summer
Structure and behavior of civil engineering materials. Laboratory investigations and test criteria. Lecture, lab. Fee. Prerequisite: ECE 313.

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

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.

Harrington Department of Bioengineering

www.fulton.asu.edu/~bme
480/965-3028
ECG 334

Eric J. Guilbeau, Chair

CORE FACULTY
Olin Endowed Professor: Guilbeau
Professors: Garcia, He, Towe
Associate Professors: Abbas, Iasemidis, Joshi, Jung, Massia, Pizziconi, Sweeney
Assistant Professors: Caplan, Muthuswamy, Panitch, Vernon
Research Professors: Brophy, Herman
Associate Research Professor: Singh
Assistant Research Professors: Helms Tillery, Shimansky
Senior Research Professional: Brandon
Research Scientists: Ehteshami, Pauken
Senior Lecturer: Coursen

AFFILIATED FACULTY

Electrical Engineering
Professor: Kozicki
Associate Professor: Kim

Electronics and Computer Engineering Technology (East campus)
Associate Professor: Macia

Kinesiology
Associate Professor: Santello

The faculty in the Harrington Department of Bioengineering offer the BSE 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 271.

BIOENGINEERING—BSE

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 principles 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 in students 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 BSE 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 88.

COURSE REQUIREMENTS

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

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

— — or — —

ENG 105 Advanced First-Year Composition (3)
HARRINGTON DEPARTMENT OF BIOENGINEERING

Elective chosen with an advisor (3)

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 SB .......................3
or ECN 112 Microeconomic Principles SB (3)
HU/SB and awareness area courses ........................................12

Total ..............................................................................15

Literacy and Critical Inquiry
BME 413 Biomedical Instrumentation L ................................3
BME 423 Biomedical Instrumentation Laboratory L .............1
ECE 300 Intermediate Engineering Design L ....................3

Total ..................................................................................7

Natural Sciences/Basic Sciences
CHM 113 General Chemistry SQ .................................4
CHM 116 General Chemistry SQ .................................4
PHY 121 University Physics I: Mechanics SQQ ..........................3
PHY 122 University Physics Laboratory I SQQ .......................1
PHY 131 University Physics II: Electricity and Magnetism SQQ ........................................3
PHY 132 University Physics Laboratory II SQQ ......................1

Total ...................................................................................16

Mathematical Studies
ECE 100 Introduction to Engineering Design CS ...............3
ECE 384 Numerical Methods for Engineers ......................4
MAT 270 Calculus with Analytic Geometry 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

Total ...................................................................................22

Engineering Core
ECE 201 Electrical Networks I .........................................4
ECE 214 Engineering Mechanics .....................................4
ECE 334 Electronic Circuits .............................................4
ECE 340 Thermodynamics .............................................3
ECE 350 Structure and Properties of Materials ............3

Total ...................................................................................18

Major
BIO 188 General Biology II SQQ .................................4
or MBB 245 Cellular and Molecular Biology SQQ (3)
and MBB 246 Cellular and Molecular Biology Laboratory SQQ (1)
BME 101 Introduction to Bioengineering .........................3
BME 235 Physiology for Engineers ...............................4
BME 318 Biomaterials .................................................3
BME 331 Biomedical Transport Phenomena ....................3
BME 350 Signals and Systems for Bioengineers .............3
BME 417 Biomedical Engineering Capstone Design I ......3
BME 470 Microcomputer Applications in Bioengineering ...4
BME 490 Biomedical Engineering Capstone Design II ......3
CSE 100 Principles of Programming with C++ CS ..........3
ECE 380 Probability and Statistics for Engineering Problem Solving CS ........................................3

Technical electives ................................................................8

Total ...................................................................................44

1 Both BME 413 and 423 must be taken to secure L credit.
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 To fulfill medical school admission requirements, premedical students generally should choose BIO 188. Note that BIO 187
   General Biology I is required by many medical schools in addition to BIO 188 and the other degree requirements and cannot
   generally be used as a technical elective.
5 Both MBB 245 and 246 must be taken to secure SQ credit. Students who pursue this major fulfill this GS requirement through
   other courses.
6 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 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 one of these 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 434 Applications of Bioengineering Transport Phenomena .........................................................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 ................................3
- 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 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

**Rehabilitation Engineering**
- IEE 437 Human Factors Engineering ....................................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, 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

**Biomedical Engineering**
- IND 354 Principles of Product Design ....................................3
- BIO 411 Biomedical Engineering I .......................................3
- BIO 412 Biomedical Engineering II .....................................3
- BIO 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
- 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 $L$ .........................4
 or MBB 343 Genetic Engineering and Society $L$ (4)
BME 494 ST: Cell Biotechnology Lab .................................3
BME 494 ST: Introduction to Molecular, Cellular, and
 Tissue Engineering ................................................................3
CHE 475 Biochemical Engineering
 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 excel-
lent 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 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 I is
required in addition to BIO 188 General Biology II as well
as the other 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 $MA$ ...............4
Total ..................................................................................13

**Second Semester**
BME 101 Introduction to Bioengineering .........................3
CHM 113 General Chemistry $SQ$ ..................................4
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 ..................................................................................18

**Second Year**

**First Semester**
BIO 188 General Biology II $SQ^3$ .................................4
 or MBB 245 Cellular and Molecular Biology $SQ^4$ (3)
 and MBB 246 Cellular and Molecular Biology
 Laboratory $SQ^4$ (1)
CHM 116 General Chemistry $SQ$ ..................................4
MAT 272 Calculus with Analytic Geometry III $MA$ ...............4
PHY 131 University Physics II: Electricity and
 Magnetism $SQ^3$ ................................................................3
PHY 132 University Physics Laboratory II $SQ^5$ .................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 $SB$ .........................3
 or ECN 112 Microeconomic Principles $SB$ (3)
MAT 274 Elementary Differential Equations $MA$ ..............3
Total ..................................................................................17

**Third Year**

**First Semester**
BME 318 Biomaterials ..............................................3
ECE 214 Engineering Mechanics ..............................4
ECE 300 Intermediate Engineering Design $L$ .................3
ECE 384 Numerical Methods for Engineers .................4
HU/SB and awareness area course$^6$ ...............................3
Total ..................................................................................17

**Second Semester**
BME 331 Biomedical Transport Phenomena .................3
BME 350 Signals and Systems for Bioengineers .............3
ECE 334 Electronic Circuits .........................................4
ECE 340 Thermodynamics ........................................3
HU/SB and awareness area course$^6$ ...............................3
Technical elective(s) .......................................................3
Total ..................................................................................16

**Fourth Year**

**First Semester**
BME 413 Biomedical Instrumentation $L^7$ ....................3
BME 417 Biomedical Engineering Capstone Design I ........3
BME 423 Biomedical Instrumentation Laboratory $L^7$ ..........1
ECE 380 Probability and Statistics for Engineering Problem
Solving $CS$ .................................................................1
HU/SB and awareness area course$^6$ ...............................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$^6$ ...............................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 To fulfill medical school admission requirements, premedical
 students generally should choose BIO 188. Note that BIO 187
 General Biology I is required by many medical schools in addi-
tion to BIO 188 and the other degree requirements and cannot
 generally be used as a technical elective.
4 Both MBB 245 and 246 must be taken to secure SQ credit. Students
 who pursue this major fulfill this GS requirement through
 other courses.
5 Both PHY 131 and 132 must be taken to secure SQ credit.
6 Engineering students may not use aerospace studies (AES) or
 military science (MIS) courses to fulfill HU and SB require-
 ments.
7 Both BME 413 and 423 must be taken to secure L credit.
BIOENGINEERING (BME)

BME 101 Introduction to Bioengineering. (3)
tell 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).

BME 235 Physiology for Engineers. (4)
tell and spring
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)
tell and 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 Bioengineering Transport Phenomena. (3)
tell
Transport phenomena with emphasis on momentum, energy, and mass transport in living systems, medical devices, and other therapeutic/diagnostic applications. Prerequisites: ECE 210 or 214; MAT 274; PHY 131, 132. Pre- or corequisite: ECE 340 recommended.

BME 350 Signals and Systems for Bioengineers. (3)
spring
Applies principles of calculus and ordinary differential equations to analysis and computer processing of biosignals and linear modeling of 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 434.

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)
tell
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.

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)
tell
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)
tell
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)
tell
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)
tell
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.

BME 434 Applications of Bioengineering Transport Phenomena. (3)
spring
Develops mathematical models of transport phenomena in physiological systems, medical devices, and pharmakokinetic analysis. Prerequisite: ECE 380. Prerequisite with a grade of “C” (2.00) or higher: BME 331.

BME 451 Cell Biotechnology Laboratory. (3)
tell
Mammalian cell culture techniques, including mouse embryonic stem cells, the use of bioreactors, cell fractionation, and digital video imaging. Lecture, 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: at least 5 of the 7 following courses: BME 318, 331, 350, 413, 470; ECE 340, 380.

BME 499 Individualized Instruction. (1–3)
Lecture, lab. Fee. Prerequisite with a grade of “C” (2.00) or higher: BME 235. BME 413 and 423 recommended.

BME 490 Biomedical Engineering Capstone Design II. (3–4)
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 Lab. (3)
Fee.
• Introduction to Molecular, Cellular, and Tissue Engineering. (3)
• Scanning Probe Microscopy. (3)

BME 496 Professional Seminar. (1–3)
tell 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/catalog on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see “Graduate-Level Courses,” page 62.
Chemical engineering students major in materials science and engineering will acquire the skills, techniques, and knowledge necessary to understand and apply their knowledge. Graduates of the Department of Chemical and Materials Engineering are prepared for jobs in manufacturing and the environment. Their training includes the science and experience necessary to develop new materials and to understand the chemical changes that may also occur. 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 students by providing a unique learning environment that encourages them to take responsibility for their education; exposes students to a diversity of viewpoints and teaching/learning styles; prepares students to work in teams to solve real-world, multidisciplinary problems; and sets them on a path of lifelong 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 BSE 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 88.

**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 below ................................. 6

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG 101 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENG 102 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENG 105 Advanced First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>Elective chosen with an advisor</td>
<td>3</td>
</tr>
<tr>
<td>ENG 107 English for Foreign Students</td>
<td>3</td>
</tr>
<tr>
<td>ENG 108 English for Foreign Students</td>
<td>3</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 6

**General Studies/School Requirements**

*Humanities and Fine Arts/Social and Behavioral Sciences*

ECN 111 Macroeconomic Principles SB ......................................... 3

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>or ECN 112 Microeconomic Principles SB</td>
<td>3</td>
</tr>
<tr>
<td>HU/SB and awareness area courses</td>
<td>12</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 15

*Literacy and Critical Inquiry*

CHE 462 Process Design L ............................................................. 3

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 300 Intermediate Engineering Design L</td>
<td>3</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 6

*Natural Sciences/Basic Sciences*

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 113 General Chemistry SQ</td>
<td>4</td>
</tr>
<tr>
<td>CHM 116 General Chemistry SQ</td>
<td>4</td>
</tr>
<tr>
<td>CHM 331 General Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHM 335 General Organic Chemistry Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics SQ</td>
<td>3</td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory I SQ</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHY 131 University Physics II: Electricity and Magnetism SQ</td>
<td>3</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 19

**Mathematical Studies**

ECE 100 Introduction to Engineering Design CS .......................... 3

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 384 Numerical Methods for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I MA</td>
<td>4</td>
</tr>
<tr>
<td>MAT 271 Calculus with Analytic Geometry II MA</td>
<td>4</td>
</tr>
<tr>
<td>MAT 272 Calculus with Analytic Geometry III MA</td>
<td>4</td>
</tr>
<tr>
<td>MAT 274 Elementary Differential Equations MA</td>
<td>3</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 22

General Studies/school requirements total .................................. 62

**Engineering Core**

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 311 Introduction to Chemical Processing</td>
<td>3</td>
</tr>
<tr>
<td>CHE 342 Introduction to Applied Chemical Thermodynamics</td>
<td>4</td>
</tr>
<tr>
<td>CHE 461 Process Control CS</td>
<td>4</td>
</tr>
<tr>
<td>ECE 350 Structure and Properties of Materials</td>
<td>3</td>
</tr>
<tr>
<td>ECE Core elective</td>
<td>3</td>
</tr>
</tbody>
</table>

Total ............................................................................................... 17

**Major**

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 331 Introduction to Transport Phenomena I: Fluids</td>
<td>3</td>
</tr>
<tr>
<td>CHE 334 Introduction to Transport Phenomena II: Heat and Mass Transfer</td>
<td>4</td>
</tr>
<tr>
<td>CHE 352 Transport Laboratories</td>
<td>2</td>
</tr>
<tr>
<td>CHE 432 Principles of Chemical Engineering Design</td>
<td>2</td>
</tr>
<tr>
<td>CHE 433 Modern Separations</td>
<td>3</td>
</tr>
<tr>
<td>CHE 442 Introduction to Chemical Reactor Design</td>
<td>3</td>
</tr>
<tr>
<td>CHE 451 Chemical Engineering Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>CHM 332 General Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>ECE 380 Probability and Statistics for Engineering Problem Solving CS</td>
<td>3</td>
</tr>
</tbody>
</table>

Technical electives ........................................................................ 18

Total ............................................................................................... 43

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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.
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 Bioseparation 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 BSE degree in Chemical 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
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 ....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 ST: Biotechnology Techniques .................................3
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 ....3

**Chemical 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
Total ..................................................................................14

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

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IRA A. FULTON SCHOOL OF ENGINEERING

Second Year

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

Second Semester
CHE 331 Introduction to 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 MA ....4
HU/SB and awareness area course ...............................3
Total ........................................................................17

Third Year

First Semester
CHE 334 Introduction to Transport Phenomena II: Heat and 
  Mass Transfer ........................................................4
CHE 342 Introduction to Applied Chemical Thermodynamics ...4
CHM 331 General Organic Chemistry ....................3
CHM 335 General Organic Chemistry Laboratory ....1
ECE 300 Intermediate Engineering Design L ............3
Total ........................................................................15

Second Semester
CHE 352 Transport Laboratories ................................2
CHE 433 Modern Separations ....................................3
CHE 442 Introduction to 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 CS ...................................4
HU/SB and awareness area course ...............................3
Technical electives ....................................................6
Total ........................................................................17

Second Semester
CHE 462 Process Design L ..........................................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—BSE

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 pro-
duction, 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 disci-
plines.

The Materials Science and Engineering degree program 
at ASU has outstanding faculty who have national reputa-
tions in the areas of both structural and electronic materials. 
The faculty bring significant professional expertise to class-
room 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 publica-
tions. Examples of recent patent applications include an 
Improved method for producing artificial Teflon arteries and 
and an improved technique for testing steel in air bag containers. 
Such preparation and experiences give the program’s 
graduates an edge in seeking employment at the best com-
panies 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 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 engineer-
ing 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 opportu-
nities available in graduate school, industry, and govern-
ment; 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 BSE 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 88.

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

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 courses .................................... 12
Total ............................................................................................. 15

Literacy and Critical Inquiry
   ECE 300 Intermediate Engineering Design L .......................... 3
   MSE 482 Materials Engineering Design L ............................... 3
Total ............................................................................................. 6

Natural Sciences/Basic Sciences
   CHM 113 General Chemistry SQ ............................................ 4
   CHM 116 General Chemistry SQ ............................................ 4
   PHY 121 University Physics I: Mechanics SQ1 ...................... 3
   PHY 122 University Physics Laboratory I SQ1 ..................... 1
   PHY 131 University Physics II: Electricity and Magnetism SQ2 ............................................ 3
   PHY 132 University Physics Laboratory II SQ2 ..................... 1
Total ............................................................................................. 16

Mathematical Studies
   ECE 100 Introduction to Engineering Design CS ..................... 3
   MAT 242 Elementary Linear Algebra ..................................... 2
   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
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 CS ........................................................................... 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 ...................................................4
ECE 436 Fundamentals of Solid-State Devices ...............................3
ECE 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
ECE 313 Introduction to Deformable Solids ................................3
ECE 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
IIE 369 Work Analysis and Design .............................................3
IIE 461 Production Control .......................................................3
IIE 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

Second Semester
CHM 116 General Chemistry SQ ..............................................4
ENG 102 First-Year Composition ..............................................3
MAT 271 Calculus with Analytic Geometry II MA .......................4
PHY 121 University Physics I: Mechanics SQ1 ........................3
PHY 122 University Physics Laboratory I SQ1 ........................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 MA .......................4
PHY 131 University Physics II: Electricity and Magnetism SQ2 ..........3
PHY 132 University Physics Laboratory II SQ2 ........................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 CS ..................................................3
MAT 274 Elementary Differential Equations MA .......................3
Technical elective .................................................................3
Total ...........................................................16

Third Year

First Semester
ECE 300 Intermediate Engineering Design L ..............................3
ECN 111 Macroeconomic Principles SB ......................................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
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 require-
   ments.

GRADUATE STUDY

The faculty in the Department of Chemical and Materials
Engineering also offer graduate programs leading to the
MS, MSE, and PhD 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 Introduction to Transport Phenomena I: Fluids. (3)
spring
Transport phenomena, with emphasis on fluid systems. Credit is
allowed for only CHE 331 or 501. Prerequisites: CHE 311; MAT 274.

CHE 334 Introduction to Transport Phenomena II: Heat and Mass
Transfer. (4)
fall
Applies heat and mass transport principles. Design of heat
exchangers and continuous contactors. Credit is allowed for only CHE
334 or 502. Prerequisite: CHE 331.

CHE 342 Introduction to Applied Chemical Thermodynamics. (4)
fall
Applies conservation and accounting principles with nonideal property
estimation techniques. Lecture, recitation. Credit is allowed for only
CHE 342 or 504. Prerequisite: CHE 311; ECE 350. 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. 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 Introduction to Chemical Reactor Design. (3)
spring
Applies kinetics to chemical reactor design. Lecture, recitation. Credit
is allowed for only CHE 442 or 505. 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.
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 ECE 350 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)
• Computer Modeling
Fee.
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,
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: Allenby, Fox, Houston, Johnson, Mamlouk, Mays, Mobasher, Rajan, Rittmann, Singhal, Witczak
Associate Professors: Abbaszadegan, Fafitis, Kavazanjian, Muccino, Westerhoff
Assistant Professors: Allen, Kaloush, Peccia
Associate Research Professor: Chen
Assistant Research Professor: El-Basyouny
Faculty Research Associates: Alum, Kabiri-Badr, 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 BSE 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, construction, 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 in 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 consideration to cost and 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 BSE degree in Civil Engineering offers students a wide background in various areas of study within civil engineering. The degree provides basic principles of construction, environmental, geotechnical/geoenvironmental, structural/materials, transportation/materials, and water resources engineering. Students have the option to select from a certain number of design and technical elective courses in their senior year.

Civil Engineering with Construction Engineering Concentration. The BSE 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 traditional engineering principles, construction materials and practice, quality control, and civil engineering project management.

Civil Engineering with Environmental Engineering Concentration. The BSE 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—BSE

The BSE 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 BSE 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)

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)

Total ...................................................................................... 6

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 course(s) ........................................................... 6–9
SB courses .............................................................. 3–6
Minimum total .......................................................... 15

Literacy and Critical Inquiry
ECE 300 Intermediate Engineering Design L .............. 3
CEE 486 Integrated Civil Engineering Design L ......... 3
Total ...................................................................................... 6

Natural Sciences/Basic Sciences
CHM 114 General Chemistry for Engineers SQ .......... 4
or CHM 116 General Chemistry SQ (4)

PHY 121 University Physics I: Mechanics SQ1 .......... 3
PHY 122 University Physics Laboratory I SQ1 .......... 1
PHY 131 University Physics II: Electricity
and Magnetism SQ2 .................................................. 3
PHY 132 University Physics Laboratory II SQ2 .......... 1

Basic science elective .................................................. 3
Total ...................................................................................... 15

Mathematical Studies
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
ECE 384 Numerical Methods for Engineers .............. 4
Total ...................................................................................... 19
General Studies/school requirements total ................. 55

Engineering Core

ECE 100 Introduction to Engineering Design CS ...... 3
ECE 201 Electrical Networks I .................................. 4
or ECE 340 Thermodynamics (3)
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 412 Pavement Analysis and Design .................. 3
or CEE 475 Highway Geometric Design (3)
CEE 420 Steel Structures ............................................. 3
or CEE 421 Concrete Structures (3)
CEE 441 Water Resources Engineering ................. 3
### Design Courses for the Degree with the Environmental Engineering Concentration

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CEE 441 Water Resources Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CEE 466 Sanitary Systems Design</td>
<td>3</td>
</tr>
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### Technical Courses for the Degree with the Environmental Engineering Concentration

<table>
<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>BIO 320 Fundamentals of Ecology</td>
<td>3</td>
</tr>
<tr>
<td>* or BCH 361 Principles of Biochemistry (3)</td>
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<tr>
<td>or CHM 302 Environmental Chemistry (3)</td>
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<tr>
<td>or CHM 341 Elementary Physical Chemistry (3)</td>
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<tr>
<td>or PUP 442 Environmental Planning (3)</td>
<td></td>
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<tr>
<td>or PUP 475 Environmental Impact Assessment (3)</td>
<td></td>
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<tr>
<td>CEE 362 Unit Operations in Environmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CEE 440 Engineering Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 467 Environmental Microbiology</td>
<td>4</td>
</tr>
<tr>
<td>Technical elective*</td>
<td>3</td>
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<td>Total</td>
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</table>

* 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

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>First</td>
<td>CHM 114 General Chemistry for Engineers SQ</td>
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<td>or CHM 116 General Chemistry SQ (4)</td>
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<td>ECE 100 Introduction to Engineering Design CS</td>
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<td>ENG 101 First-Year Composition</td>
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<td></td>
<td>MAT 270 Calculus with Analytic Geometry I MA</td>
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#### Second Semester

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<td>CEE 296 Civil Engineering Systems</td>
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<td></td>
<td>ECN 111 Macroeconomic Principles SB</td>
<td>3</td>
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<td></td>
<td>or ECN 112 Microeconomic Principles SB (3)</td>
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<tr>
<td></td>
<td>ENG 102 First-Year Composition</td>
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<td></td>
<td>MAT 271 Calculus with Analytic Geometry II MA</td>
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<tr>
<td></td>
<td>PHY 121 University Physics I: Mechanics SQ</td>
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<td></td>
<td>PHY 122 University Physics Laboratory I SQ</td>
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#### Second Year

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<tr>
<td>First</td>
<td>ECE 210 Engineering Mechanics I: Statics</td>
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<tr>
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<td>MAT 272 Calculus with Analytic Geometry III MA</td>
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<td>MAT 274 Elementary Differential Equations MA</td>
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<tr>
<td></td>
<td>PHY 131 University Physics II: Electricity and Magnetism SQ</td>
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<tr>
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<td>PHY 132 University Physics Laboratory II SQ</td>
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<td></td>
<td>HU/SB and awareness area course</td>
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#### Second Semester

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<td>Second</td>
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<td>or ECE 340 Thermodynamics (3)</td>
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### IRA A. FULTON SCHOOL OF ENGINEERING

<table>
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<th>Course Code</th>
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<tbody>
<tr>
<td>ECE 212</td>
<td>Engineering Mechanics II: Dynamics</td>
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<tr>
<td>ECE 313</td>
<td>Introduction to Deformable Solids</td>
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<tr>
<td>ECE 380</td>
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**Third Year**

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<tr>
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<td>CEE 321</td>
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<td>ECE 351</td>
<td>Civil Engineering Materials</td>
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<td>ECE 384</td>
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<td>Fluid Mechanics for Civil Engineers</td>
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<td>CEE 361</td>
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**Fourth Year**

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**Construction Engineering Concentration**

### Program of Study

A Four-Year Sequence

**First Year**

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**Second Semester**

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<td>ECE 111</td>
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<tr>
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<td>Microeconomic Principles SB (3)</td>
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<td>ENG 102</td>
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<tr>
<td>MAT 271</td>
<td>Calculus with Analytic Geometry II MA</td>
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**Second Year**

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**First Semester**

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<td>Elementary Differential Equations MA</td>
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<td>PHY 131</td>
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<td>PHY 132</td>
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**Third Year**

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<tbody>
<tr>
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<tr>
<td>CEE 372</td>
<td>Transportation Engineering</td>
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<tr>
<td>ECE 300</td>
<td>Intermediate Engineering Design L</td>
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<td>ECE 351</td>
<td>Civil Engineering Materials</td>
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<td>ECE 384</td>
<td>Numerical Methods for Engineers</td>
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**Fourth Year**

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<td>CEE 381</td>
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<td>CEE 420</td>
<td>Steel Structures</td>
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<td>CEE 452</td>
<td>Foundations</td>
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<td>CEE 481</td>
<td>Civil Engineering Project Management</td>
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<tr>
<td>MAT 496</td>
<td>Construction Contract Administration L</td>
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**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.
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Environmental Engineering Concentration
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 101 Introduction to Engineering Design CS..................3
ENG 102 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 104 First-Year Composition..........................................3
MAT 271 Calculus with Analytic Geometry II MA..............4
PHY 121 University Physics I: Mechanics SQ1.................3
PHY 122 University Physics Laboratory I SQ1..................3
Total .................................................................18

Second Year

First Semester
ECE 210 Engineering Mechanics I: Statics..........................3
MAT 272 Calculus with Analytic Geometry III MA............4
MAT 274 Elementary Differential Equations MA...............3
PHY 131 University Physics II: Electricity and
Magnetism SQ2..................................................................3
PHY 132 University Physics Laboratory II SQ2.................1
HU/SB and awareness area course3....................................3
Total .................................................................17

Second Semester
CHM 231 Elementary Organic Chemistry SQ4..................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 CS........................................................................3
Total .................................................................15

Third Year

First Semester
CEE 321 Structural Analysis and Design.........................4
CEE 372 Transportation Engineering.................................4
ECE 300 Intermediate Engineering Design L....................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 course3....................................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 course3....................................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 L................3
HU/SB and awareness area course3....................................3
Technical elective3.............................................................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. Stu-
dents who pursue this major fulfill this SQ requirement through
other courses.
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 88.

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—BSD1 Lower-Division Requirements,” page 141.

GRADUATE STUDY

The Department of Civil and Environmental Engineering
also offers graduate programs leading to the MS, MSE, and
PhD degrees. These programs provide a blend of classroom
instruction and research. Many topics and relevant research

L literacy and critical inquiry / MA mathematics / CS computer/statistics/
quantitative applications / HU humanities and fine arts / SB social and
behavioral sciences / SQ natural science—general core courses / SQ natural
science—quantitative / C cultural diversity in the United States / G global / H
historical / See “General Studies,” page 92.
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: CEE 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 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 design. 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. Lecture, recitation. Prerequisite: CEE 321.

CEE 420 Steel Structures. (3) fall

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. Rainfall 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 456 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, freeways, and interchanges. Lecture, computer lab. Fee. Credit is allowed for only CEE 475 or 576. 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) fall
Properties of highway materials, including aggregates, asphalt concrete, and portland cement concrete; construction practice; material delivery, placement, and compaction; quality control. Lecture, field trips. Credit is allowed for only CEE 483 or 583. 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 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
**Department of Computer Science and Engineering**

cse.asu.edu
480/965-3190
BYENG

Sethuraman Panchanathan, Chair


Associate Professors: Bazzi, Candan, Dasgupta, Dietrich, Faltz, Gupta, Huey, Liu, Miller, Richa, Sen, Xue

Assistant Professors: Cam, Chatha, Davulcu, Kim, Konjevod, Li, Ryu, Sarjoughian, Sundaram, Syrotiuk, Wonka

Senior Lecturer: DeLibero

Lecturers: Boyd, Calliss, 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; for the automatic control and simulation of processes; and for information assurance.

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 BS degree in Computer Science and a BSE 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 to continue learning independently and growing 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

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or---

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<td>MAT 272</td>
<td>Calculus with Analytic Geometry III MA</td>
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<td>University Physics I: Mechanics SQ</td>
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</tr>
</tbody>
</table>

**L** literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SQ** natural science—general core courses / **G** global / **H** historical / See “General Studies,” page 92.
PHY 131 University Physics II: Electricity and Magnetism $S_Q^2$..........................3
PHY 132 University Physics Laboratory II $S_Q$........................................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 BS degree in Computer Science and the BSE 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 that 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 88.

DEGREES

Computer Science—BS

The faculty in the Department of Computer Science and Engineering offer a BS degree that prepares the student for a career in computer science. A student pursuing a BS 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 BS degree in Computer Science may choose to concentrate their studies on software engineering. The BS 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 course.

The following table specifies departmental requirements for the BS 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

Humanities and Fine Arts/Social and Behavioral Sciences
HU/SB electives..................................................................................18

Literacy and Critical Inquiry
L elective..........................................................................................3
ECE 400 Engineering Communications........................................3
or approved CSE L course (3)

Total ........................................................................................................6

Natural Sciences/Basic Sciences

PHY 121 University Physics I: Mechanics $S_Q^1$.................................3
PHY 122 University Physics Laboratory I $S_Q$.................................1
PHY 131 University Physics II: Electricity and Magnetism $S_Q^2$............3
PHY 132 University Physics Laboratory II $S_Q^2$.................................1
Science elective$^3$...............................................................................4

Total .......................................................................................................12

Mathematical Studies

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

---
## Computer Science Program of Study

### Typical Four-Year Sequence

#### First Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 200 Concepts of Computer Science CS</td>
<td>3</td>
</tr>
<tr>
<td>ENG 101 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I MA</td>
<td>4</td>
</tr>
<tr>
<td>HU/SB and awareness area course</td>
<td>1</td>
</tr>
<tr>
<td>Unrestricted elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
</tr>
</tbody>
</table>

#### Second Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 120 Digital Design Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>CSE 210 Object-Oriented Design and Data Structures CS</td>
<td>3</td>
</tr>
<tr>
<td>ENG 102 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>MAT 271 Calculus with Analytic Geometry II MA</td>
<td>4</td>
</tr>
<tr>
<td>Unrestricted elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
</tr>
</tbody>
</table>

#### Second Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 240 Introduction to Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>MAT 243 Discrete Mathematical Structures</td>
<td>3</td>
</tr>
<tr>
<td>MAT 272 Calculus with Analytic Geometry III MA</td>
<td>4</td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics SQ</td>
<td>3</td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory II SQ</td>
<td>1</td>
</tr>
<tr>
<td>HU/SB and awareness area course</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
</tr>
</tbody>
</table>

#### Third Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 310 Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 330 Computer Organization and Architecture</td>
<td>3</td>
</tr>
<tr>
<td>CSE 360 Introduction to Software Engineering</td>
<td>3</td>
</tr>
<tr>
<td>HU/SB and awareness area course</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory Science SQ</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
</tr>
</tbody>
</table>

#### Fourth Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 430 Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECE 400 Engineering Communications</td>
<td>3</td>
</tr>
<tr>
<td>or approved CSE L course (3)</td>
<td></td>
</tr>
<tr>
<td>400-level CSE computer science breadth electives</td>
<td>9</td>
</tr>
<tr>
<td>Unrestricted elective</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15</td>
</tr>
</tbody>
</table>

### Notes
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—BSE

The Department of Computer Science and Engineering offers a BSE degree that prepares students for careers 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...
**IRA A. FULTON SCHOOL OF ENGINEERING**

The following table specifies departmental requirements for the BSE degree in Computer Systems Engineering.

**First-Year Composition**
Choose among the course combinations below...

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG 101 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENG 102 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

**General Studies/Department Requirements**

<table>
<thead>
<tr>
<th>Humanities and Fine Arts/Social and Behavioral Sciences</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECN 111 Macroeconomic Principles</td>
<td>3</td>
</tr>
<tr>
<td>or ECN 112 Microeconomic Principles</td>
<td></td>
</tr>
<tr>
<td>HU and SB electives</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

**Literacy and Critical Inquiry**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 423 Capstone Project L</td>
<td>3</td>
</tr>
<tr>
<td>CSE 300 Intermediate Engineering Design L</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

**Natural Sciences/Basic Sciences**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 114 General Chemistry for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>or CHM 116 General Chemistry</td>
<td></td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>PHY 131 University Physics II: Electricity</td>
<td>3</td>
</tr>
<tr>
<td>or Magnetism</td>
<td></td>
</tr>
<tr>
<td>PHY 132 University Physics Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>PHY 361 Introductory Modern Physics</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

**Mathematical Studies**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 243 Discrete Mathematical Structures</td>
<td>3</td>
</tr>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td>MAT 271 Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>MAT 272 Calculus with Analytic Geometry III</td>
<td>4</td>
</tr>
<tr>
<td>MAT 274 Elementary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>or MAT 275 Modern Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MAT 342 Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>or MAT 343 Applied Linear Algebra</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
</tr>
</tbody>
</table>

**Engineering Core**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 200 Concepts of Computer Science CS</td>
<td>3</td>
</tr>
<tr>
<td>CSE 225 Assembly Language Programming and</td>
<td></td>
</tr>
<tr>
<td>Microprocessors (Motorola)</td>
<td></td>
</tr>
<tr>
<td>ECE 100 Introduction to Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td>ECE 201 Electrical Networks I</td>
<td>3</td>
</tr>
<tr>
<td>ECE 210 Engineering Mechanics I: Statics</td>
<td>3</td>
</tr>
<tr>
<td>ECE 334 Electronic Circuits</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
</tr>
</tbody>
</table>

**Computer Science Core**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 120 Digital Design Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>CSE 210 Object-Oriented Design and Data</td>
<td>3</td>
</tr>
<tr>
<td>Structure CS</td>
<td></td>
</tr>
<tr>
<td>CSE 240 Introduction to Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CSE 310 Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 330 Computer Organization and Architecture</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
</tr>
</tbody>
</table>

**Computer Systems Engineering**

**Program of Study**

**Typical Four-Year Sequence**

**First Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 200 Concepts of Computer Science CS</td>
<td>3</td>
</tr>
<tr>
<td>ECE 200 Concepts of Computer Science CS</td>
<td>3</td>
</tr>
<tr>
<td>or CSE 120 Digital Design Fundamentals</td>
<td></td>
</tr>
<tr>
<td>or ECE 100 Introduction to Engineering Design CS (3)</td>
<td></td>
</tr>
<tr>
<td>ECN 111 Macroeconomic Principles</td>
<td>3</td>
</tr>
<tr>
<td>or ECN 112 Microeconomic Principles</td>
<td></td>
</tr>
<tr>
<td>HU 101 First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Second Semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 114 General Chemistry for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CSE 120 Digital Design Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>or ECE 100 Introduction to Engineering Design CS (3)</td>
<td></td>
</tr>
<tr>
<td>CSE 210 Object-Oriented Design and Data</td>
<td>3</td>
</tr>
<tr>
<td>Structure CS</td>
<td></td>
</tr>
<tr>
<td>ECE 210 Engineering Mechanics I: Statics</td>
<td>3</td>
</tr>
<tr>
<td>MAT 272 Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 225 Assembly Language Programming and</td>
<td></td>
</tr>
<tr>
<td>Microprocessors (Motorola)</td>
<td>4</td>
</tr>
<tr>
<td>MAT 243 Discrete Mathematical Structures</td>
<td>3</td>
</tr>
<tr>
<td>MAT 272 Calculus with Analytic Geometry III</td>
<td>4</td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

**Third Semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 240 Introduction to Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>ECE 201 Electrical Networks I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 274 Elementary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>or MAT 275 Modern Differential Equations</td>
<td></td>
</tr>
<tr>
<td>PHY 131 University Physics II: Electricity</td>
<td>3</td>
</tr>
<tr>
<td>or Magnetism</td>
<td></td>
</tr>
<tr>
<td>PHY 132 University Physics Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>HU/SB and awareness area course</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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 L ...................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 .................... 3
ECE 380 Probability and Statistics for Engineering Problem
Solving CS ....................................................................3
HU/SB and awareness area course3 .................................3
Total ...........................................................................16

Fourth Year

First Semester
CSE 422 Microprocessor System Design II ..................... 4
CSE 430 Operating Systems .........................................3
ECE 201 Electrical Networks I ......................................3
PHY 361 Introductory Modern Physics .........................3
HU/SB and awareness area course3 .................................3
Total ...........................................................................17

Second Semester
CSE 423 Capstone Project L .........................................3
or CSE 438 Systems Programming L (3)
ECE 334 Electronic Circuits ........................................4
HU/SB and awareness area course3 .................................3
Technical electives .........................................................6
Total ...........................................................................16

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 and SB require-
   ments.

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,
flippers, 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 solutions 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 Microproces-
sors (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 Microproces-
sors (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

L literacy and critical inquiry / MA mathematics / CS computer/statistics/
quantitative applications / HU humanities and fine arts / SB social and
behavioral sciences / NG natural science—general core courses / NG natural
science—quantitative / C cultural diversity in the United States / G global /
H historical / See “General Studies,” page 92.
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
Introduces formal language theory and automata, Turing machines, decidability/undecidability, recursive function theory, and complexity theory. Prerequisite: CSE 310.

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

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 Capstone Project. (3)
fall and spring
Development process: specification, design, implementation, evaluation, and testing with economic, social, and safety considerations. Written or oral communication skills enrichment. Fee. Prerequisite: CSE 422.

CSE 428 Computer-Aided Processes. (3)
fall and spring
Hardware and software considerations for computerized manufacturing systems. Specific concentration on automatic inspection, numerical control, robotics, and integrated manufacturing systems. Fee. Prerequisite: CSE 422.

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 433 Computer Networks. (3)
fall and spring
Cryptography fundamentals; data compression; error handling; flow control; multipath 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 linkers, I/O handlers, and schedulers. Prerequisite: CSE 421 or instructor approval.

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)
fall
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, Dijkstra's logic, proof obligations, and program proving. Prerequisite: CSE 355.

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 problems. 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 210 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.

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 BSE 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—BSE

The goal of the Electrical Engineering undergraduate program is to prepare graduates for entry-level positions as electrical engineers for the broad range of opportunities available in industrial, commercial, and governmental organizations, and to prepare 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 provide students with
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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 an 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 BSE 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 88.

COURSE REQUIREMENTS

The specific course requirements for the BSE degree in Electrical Engineering follow.

First-Year Composition

Choose among the course combinations below ..............................................6

ENG 101 First-Year Composition (3)
ENG 102 First-Year Composition (3)
- - - - or -- - --
ENG 105 Advanced First-Year Composition (3)
Elective (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

Humanities and Fine Arts/Social and Behavioral Sciences

ECTN 111 Macroeconomic Principles SB .................................................3
- or ECTN 112 Microeconomic Principles SB (3)

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

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design ...............................................3
EEC 488 Senior Design Laboratory I L ......................................................2
EEC 489 Senior Design Laboratory II L ......................................................2

Total .............................................................................................................7

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers SQ ..............................................4
- or CHM 116 General Chemistry SQ (4)

PHY 121 University Physics I: Mechanics SQ .............................................3
PHY 122 University Physics Laboratory I SQ .............................................1
PHY 131 University Physics II: Electricity and Magnetism SQ .................3

PHY 132 University Physics Laboratory II SQ .............................................1
PHY 241 University Physics III .................................................................3

Total .............................................................................................................15

Mathematical Studies

ECE 100 Introduction to Engineering Design CS ........................................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 274 Elementary Differential Equations MA .......................................3

- or MAT 275 Modern Differential Equations MA (3)
MAT 342 Linear Algebra ...........................................................................3

- or MAT 343 Applied Linear Algebra (3)
MAT 362 Advanced Mathematics for Engineers and Scientists ..................3

Total .............................................................................................................24

General Studies/school requirements total ..............................................61

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
ECE 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
EEC 120 Digital Design Fundamentals ....................................................3
EECE 302 Electrical Networks II ............................................................3
EECE 303 Signals and Systems ...............................................................3
EECE 340 Electromagnetic Engineering I ................................................4
EECE 350 Random Signal Analysis .......................................................3
EECE 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 3.00 or higher 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 the same 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 .......................3
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 ..................................................3
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 CS1 ..........3
or ECE 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 Fundamentals1 ..................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 SQ2 ..........3
PHY 122 University Physics Laboratory I SQ2 ..........1
Total ........................................................................14

Second Year
First Semester
CSE 100 Principles of Programming with C++ CS3 ........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 SQ4 ..................................................3
PHY 132 University Physics Laboratory II SQ4 ..........1
Total ........................................................................17

Second Semester
ECE 201 Electrical Networks I ..................................4
EEE 225 Assembly Language Programming and
Microprocessors (Motorola) ......................................4
or ECE 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 course5 .........................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 course5 .........................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 course5 .........................3
Total ........................................................................17

Fourth Year
First Semester
ECE 214 Engineering Mechanics .........................4
EEE 350 Random Signal Analysis ............................3
EEE 488 Senior Design Laboratory I L6 ..................2
Technical electives ................................................7
Total ........................................................................16

Second Semester
EEE 489 Senior Design Laboratory II L6 ..............2

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 92.
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HU/SB and awareness area course 5 .......................................................... 3
Technical electives .................................................................................. 11
Total ......................................................................................................... 16

1 Both ECE 100 and EEE 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 obtain 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 and spring
Analyzes linear and nonlinear networks. Analytical and numerical methods. Prerequisite: ECE 201. Pre- or corequisite: MAT 362.

EEE 303 Signals and Systems. (3)  
fall and spring
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 342; 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

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 304.

EEE 433 Analog Integrated Circuits. (4)  
fall and spring
Analysis, design, and applications of modern analog circuit technology 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, Schroedinger wave equation, probability, problems in one dimension, principles of wave mechanics, scattering, tunneling, central forces, angular momentum, hydrogen atom, perturbation theory, variational techniques. Prerequisites: ECE 352; EEE 340.

EEE 435 Microelectronics. (3)  
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.

EEE 437 Optoelectronics. (3)  
selected semesters
Basic operating principles of various types of optoelectronic devices that 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

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

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 362; 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 498 Pro-Seminar. (1–7)
Selected semesters

Topics may include the following:

• Real-Time DSP
Fee. Credit is allowed for only EEE 498 or 591.

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, Villalobos

Assistant Professors: Gel, Keha, Kulahci, Wu

Senior Lecturers: Plund, Thompson

The industrial engineer (IE) provides leadership for American organizations in establishing and maintaining 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 flows in all forms of work systems, 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, including 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 organizational 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—BSE

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 focused 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 an advanced degree in graduate school.

The suggested 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.


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 for a career 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 BSE 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 88. For information concerning admission, degree, course, and graduation requirements for the School of Engineering, see “Admission,” page 225, and subsequent sections.

COURSE REQUIREMENTS

Students take 59 semester hours of university English proficiency and general studies course work, 19 hours of engineering core courses, 35 hours of industrial engineering courses, three hours of industrial engineering electives, and 12 hours of career-focused study area electives. Each career-focused study area has an associated list of recommended study area courses. The course work for the undergraduate degree can be classified into the following categories:

**First-Year Composition**

Choose among the course combinations below .........................................................6

- ENG 101 First-Year Composition (3)
- ENG 102 First-Year Composition (3)

- 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)

Total ..................................................................................................................................6

**General Studies/School Requirements**

<table>
<thead>
<tr>
<th>Humanities and Fine Arts/Social and Behavioral Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECN 112 Microeconomic Principles SB ..........................3</td>
</tr>
<tr>
<td>or ECN 111 Macroeconomic Principles SB (3)</td>
</tr>
<tr>
<td>HU courses ...................................................................6–9</td>
</tr>
<tr>
<td>SB course(s) ...................................................................3–6</td>
</tr>
<tr>
<td>Minimum total ..........................................................15</td>
</tr>
</tbody>
</table>

**Literacy and Critical Inquiry**

| ECE 300 Intermediate Engineering Design L .................3 |

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260
Industrial and Management Systems
IEE 305 Information Systems Engineering CS..................3
IEE 431 Engineering Administration..............................3

Any approved engineering or business elective..................3

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

Global Industrial Engineering Leadership
ECN 306 Survey of International Economics SB, G..............3
IBS 300 Principles of International Business G.................3
IBS - 400 Cultural Factors in International Business C, G.....3
Any approved international business electives..................3

High-Tech Manufacturing
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 Systems1, 2
Focus area courses .........................................................12

Any approved engineering or business elective..................3

Mathematical Studies
MAT 242 Elementary Linear Algebra.............................2
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
Total ...............................................................................17

General Studies/school requirements total......................53

Natural Sciences/Basic Sciences
CHM 114 General Chemistry for Engineers SQ...............4
or CHM 116 General Chemistry SQ1 (4)
PHY 121 University Physics I: Mechanics SQ1.................3
PHY 122 University Physics Laboratory I SQ1................1
PHY 131 University Physics II: Electricity and
Magnetism SQ2 ............................................................3
PHY 132 University Physics Laboratory II SQ2.............1
Basic science elective..................................................3
Total ...............................................................................15

Engineering Core
ECE 100 Introduction to Engineering Design CS..............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 CS....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++ CS ..........3
CSE 200 Concepts of Computer Science CS ..................3
ECE 380 Probability and Statistics for Engineering Problem
Solving CS .................................................................3
IEE 210 Applications to Industrial Engineering ..........3
IEE 300 Economic Analysis for Engineers ..................3
IEE 360 Manufacturing Processes ................................3
IEE 368 Facilities Analysis and Design .................3
IEE 376 Operations Research Deterministic
Techniques/Applications CS .........................................3
IEE 385 Introduction to Engineering Probability Models CS..3
IEE 461 Production Control ....................................3
IEE 474 Quality Control CS ..................................3
IEE 475 Simulating Stochastic Systems CS ...............3
Total ...............................................................................36

Industrial Engineering Elective Area. Students select
two semester hours of industrial engineering electives. 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 one of the following
career-focused study areas:

Industrial and Management Systems
IEE 305 Information Systems Engineering CS..............3
IEE 431 Engineering Administration.........................3

Any approved engineering or business elective..................3

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
CHM 114 General Chemistry for Engineers SQ..............4
or CHM 116 General Chemistry SQ1 (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
ECN 112 Microeconomic Principles SB ......................3
or ECN 111 Macroeconomic Principles SB (3)
ENG 102 First-Year Composition.................................3
MAT 271 Calculus with Analytic Geometry II MA .........4
PHY 121 University Physics I: Mechanics SQ2 ............3
PHY 122 University Physics Laboratory I SQ2 .............1
HU/SB elective3 .........................................................3
Total ...........................................................................17

1 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 / SG natural
science—quantitative / C cultural diversity in the United States / G global / 
H historical / See “General Studies,” page 92.
## Second Year

### First Semester
- CSE 100 Principles of Programming with C++ CS: 3
- IEE 300 Economic Analysis for Engineers: 3
- MAT 242 Elementary Linear Algebra: 2
- PHY 131 University Physics II: Electricity and Magnetism: 3
- PHY 132 University Physics Laboratory II: SQ: 1
- Study area elective: 3
- Total: 17

### Second Semester
- CSE 200 Concepts of Computer Science CS: 3
- ECE 212 Engineering Mechanics II: Dynamics: 3
- IEE 210 Industrial Engineering Applications: 3
- MAT 274 Elementary Differential Equations: 3
- Basic science elective: 3
- Total: 15

### 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 CS: 3
- IEE 474 Quality Control CS: 3
- Total: 16

#### Second Semester
- ECE 212 Engineering Mechanics II: Dynamics: 3
- IEE 376 Operations Research Deterministic Techniques/Applications CS: 3
- IEE 463 Computer-Aided Manufacturing and Control CS: 3
- Study area elective: 3
- Total: 18

### Fourth Year

#### First Semester
- IEE 368 Facilities Analysis and Design: 3
- IEE 461 Production Control: 3
- IEE 475 Simulating Stochastic Systems CS: 3
- HU/SB elective: 3
- Study area elective: 3
- Industrial engineering elective: 2
- Total: 15

#### Second Semester
- IEE 490 Project in Design and Development L: 3
- HU/SB elective: 3
- Total: 6

Study area electives: 6
Total: 15

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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)

1. **IEE 210 Introduction to Industrial Engineering.** (3)  
   *fall and spring*  
   History of IE; IE career paths; ethical, social, and contemporary issues; introduction to IE techniques, methods, and their application; case studies. Prerequisite: ECE 100; sophomore standing.

2. **IEE 294 Special Topics.** (1–4)  
   *fall and spring*  
   Topics may include the following:
   - Industrial Engineering Applications Seminar: (2)

3. **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.

4. **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.

5. **General Studies: CS**

6. **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.

7. **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.

8. **IEE 368 Facilities Analysis and Design.** (3)  
   *fall*  
   Facilities 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.

9. **IEE 369 Work Analysis and Design.** (3)  
   *spring*  
   Work planning, analysis, and design of human factors, work planning, methods analysis and design, and work measurement. Applications in diverse fields. Lecture, lab. Fee. Prerequisite: IEE 300.

10. **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 modeling 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  
Covers topics of immediate or special interest to a faculty member and students.  
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. Cross-listed as MAE 453. Credit is allowed for only IEE 463 or MAE 453. 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/aadlicatalogs on the Web. In some situations, undergraduate students may be eligible to take these courses; for more information, see “Graduate-Level Courses,” page 62.
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. **Our graduates will be technically competent engineers.** Graduates will show basic understanding of the fundamental principles of mathematics, physics, and chemistry and will use them to model and predict the behavior of aerospace engineering systems.

2. **Our graduates will have the ability to design a system appropriate to the field of aerospace engineering.** Graduates will perform conceptual and preliminary design of aircraft and/or spacecraft systems or subsystems, and will include life-cycle cost and environmental impact in the design process.

3. **Our graduates will communicate effectively.** Graduates will make effective oral and written technical presentations and will document analysis and design processes.

4. **Our graduates will have the professional attributes necessary for success in the current work environment.** Graduates will be prepared for modern engineering practice by effectively working in teams, recognizing the need 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 three wind tunnels, a mechanical-testing laboratory, a measurements and controls laboratory, and a vibrations laboratory.

**DEGREE REQUIREMENTS**

A minimum of 128 semester hours of course work is necessary for the BSE degree in Aerospace Engineering, including a 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 credit hours earned more than five years before admission to the program 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 students experiencing academic difficulties.

**COURSE REQUIREMENTS**

The specific course requirements for the BSE degree in Aerospace Engineering are as follows:

**First-Year Composition**

Choose among the course combinations below

- **ENG 101 First-Year Composition (3)**
- **ENG 102 First-Year Composition (3)**
- **ENG 105 Advanced First-Year Composition (3)**
- Approved elective (3)

**Total**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG 101</td>
<td>First-Year Composition</td>
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</tr>
<tr>
<td>ENG 102</td>
<td>First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENG 105</td>
<td>Advanced First-Year Composition</td>
<td>3</td>
</tr>
<tr>
<td>Approved elective</td>
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<tr>
<td><strong>Total</strong></td>
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**General Studies/School Requirements**

- **Humanities and Fine Arts/Social and Behavioral Sciences**
  - **ECN 111 Macroeconomic Principles SB (3)**
  - **ECN 112 Microeconomic Principles SB (3)**

- **Minimum total**

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<tr>
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<th>Hours</th>
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<tr>
<td>ECN 111</td>
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<td><strong>Total</strong></td>
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</table>

**Literacy and Critical Inquiry**

- **ECE 300 Intermediate Engineering Design L (3)**
- **MAE 468 Aerospace Systems Design L (3)**
- **Total**

<table>
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<tr>
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<th>Course Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>ECE 300</td>
<td>Intermediate Engineering Design</td>
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</tr>
<tr>
<td>MAE 468</td>
<td>Aerospace Systems Design</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
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</tbody>
</table>

**Mathematical Studies**

- **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 275 Modern Differential Equations MA (3)**
- **MAT 343 Applied Linear Algebra (3)**
- **Total**

<table>
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<th>Hours</th>
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<tbody>
<tr>
<td>MAT 270</td>
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<td>MAT 271</td>
<td>Calculus with Analytic Geometry II</td>
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<tr>
<td>MAT 272</td>
<td>Calculus with Analytic Geometry III</td>
<td>4</td>
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<tr>
<td>MAT 275</td>
<td>Modern Differential Equations</td>
<td>3</td>
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<tr>
<td>MAT 343</td>
<td>Applied Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
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</table>

**Natural Sciences/Basic Sciences**

- **CHM 114 General Chemistry for Engineers SQ (4)**
- **CHM 116 General Chemistry SQ (4)**
- **PHY 121 University Physics I: Mechanics SQ (3)**
- **PHY 122 University Physics Laboratory I SQ (1)**
- **PHY 131 University Physics II: Electricity and Magnetism SQ (4)**
- **PHY 132 University Physics Laboratory II SQ (1)**
- **PHY 361 Introductory Modern Physics**
- **Total**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>CHM 114</td>
<td>General Chemistry for Engineers</td>
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<td>CHM 116</td>
<td>General Chemistry</td>
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<td>PHY 121</td>
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<td>PHY 132</td>
<td>University Physics Laboratory II</td>
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<tr>
<td>PHY 361</td>
<td>Introductory Modern Physics</td>
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<td><strong>Total</strong></td>
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**General Studies school requirements total**

<table>
<thead>
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<th>Course Title</th>
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<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
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</tbody>
</table>

**Engineering Core**

- **ECE 100 Introduction to Engineering Design CS (3)**
- **ECE 201 Electrical Networks I (4)**
- **ECE 214 Engineering Mechanics (4)**
- **ECE 313 Introduction to Deformable Solids (3)**
- **ECE 340 Thermodynamics (3)**

<table>
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<tr>
<th>Course Code</th>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>ECE 100</td>
<td>Introduction to Engineering Design</td>
<td>3</td>
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<tr>
<td>ECE 201</td>
<td>Electrical Networks I</td>
<td>4</td>
</tr>
<tr>
<td>ECE 214</td>
<td>Engineering Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>ECE 313</td>
<td>Introduction to Deformable Solids</td>
<td>3</td>
</tr>
<tr>
<td>ECE 340</td>
<td>Thermodynamics</td>
<td>3</td>
</tr>
</tbody>
</table>
ECE 350 Structure and Properties of Materials ................................. 3
Total .................................................................................................... 4

Aerospace Engineering Major
ECE 384 Numerical Methods for Engineers ....................................... 4
MAE 101 Introduction to Aerospace Engineering ............................... 2
MAE 317 Dynamic Systems and Control ........................................... 3
MAE 319 Measurements and Data Analysis ..................................... 3
MAE 361 Aerodynamics I ................................................................. 3
MAE 413 Aircraft Dynamics 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 469 Projects in Astronautics or Aeronautics (3)
Technical elective(s) ........................................................................ 4
Total .................................................................................................... 48
Total for the program ........................................................................ 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 Both AST 113 and 321 must be taken to secure SQ credit.
6 A student must attain a minimum grade of “C” to receive prerequisite credit for engineering core courses that are prerequisite to any course in the Aerospace Engineering major.
7 A “C” (2.00) average or higher is required for all courses listed under the major plus MAE 468.
8 This course is 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 student has at least a 3.00 GPA and approval of the instructor, advisor, and the school dean.

IEE 300 Economic Analysis for Engineers ....................................... 3
IEE 385 Introduction to Engineering Probability Models CS .......... 3
IEE 463 Computer-Aided Manufacturing and Control CS ............ 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
MAE 421 Applied Computational Methods CS ............................. 3
MAT 423 Numerical Analysis I CS ............................................... 3
MAT 425 Numerical Analysis II CS .............................................. 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 SQ ......................... 4
or CHM 116 General Chemistry SQ (4)
ECE 100 Introduction to Engineering Design CS ....................... 3
ENG 101 First-Year Composition .................................................. 3
MAE 101 Introduction to Aerospace Engineering ....................... 2
MAT 270 Calculus I MA .............................................................. 4
Total .................................................................................................... 16

Second Semester
ENG 102 First-Year Composition .................................................. 3
MAT 271 Calculus with Analytic Geometry II MA ....................... 4
MAT 275 Modern Differential Equations MA ............................... 3
PHY 121 University Physics I: Mechanics SQ .............................. 3
PHY 122 University Physics Laboratory I SQ .............................. 1
HU/SB electives .............................................................................. 3
Total .................................................................................................... 17

Second Year

First Semester
ECE 214 Engineering Mechanics .................................................. 4
MAT 272 Calculus with Analytic Geometry III MA ....................... 4
MAT 343 Applied Linear Algebra .................................................. 4
PHY 131 University Physics II: Electricity and Magnetism SQ ....... 3
PHY 132 University Physics Laboratory II SQ .............................. 1
Total .................................................................................................... 15

Second Semester
ECE 201 Electrical Networks I ...................................................... 4
ECE 313 Introduction to Deformable Solids .................................. 3
ECE 340 Thermodynamics .......................................................... 3
ECE 350 Structure and Properties of Materials ......................... 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 Dynamics and Control ................................. 3
MAE 444 Fundamentals of Aerospace Design .............................. 3
MAE 460 Gas Dynamics ............................................................ 3
PHY 361 Introductory Modern Physics or AST 321 Introduction to Planetary and Stellar Astrophysics SQ1 (3)
HU/SB elective2 .......................................................................... 3
Total .......................................................................................... 15

Fourth Year
MAE 415 Vibration Analysis ....................................................... 4
MAE 462 Space Vehicle Dynamics and Control .......................... 3
MAE 463 Propulsion ................................................................. 3
MAE 464 Aerospace Laboratory ................................................ 3
HU/SB elective2 .......................................................................... 3
Technical electives ..................................................................... 4
Total .......................................................................................... 16

Notes:
1 Both PHY 121 and 122 must be taken to secure SQ credit.
2 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to obtain HU or SB requirements.
3 Both PHY 131 and 132 must be taken to secure SQ credit.
4 Both AST 113 and 321 must be taken to secure SQ credit.

MECHANICAL ENGINEERING – BSE

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, a mechanical-testing laboratory, a measurements and controls laboratory, and a manufacturing laboratory.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the BSE degree in Mechanical Engineering, including a 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 credit hours earned more than five years before admission to the program 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
DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

minimum GPA of 2.00 in the major and overall. The department may require additional or remedial course work for students experiencing academic difficulties.

COURSE REQUIREMENTS

The specific course requirements for the BSE degree in Mechanical Engineering are as follows:

First-Year Composition
Choose among the course combinations below.

- ENG 101 First-Year Composition (3)
- ENG 102 First-Year Composition (3)
- ENG 105 Advanced First-Year Composition (3)
- Approved elective (3)
- ENG 107 English for Foreign Students (3)
- ENG 108 English for Foreign Students (3)

Total: 15

Literacy and Critical Inquiry

ECE 300 Intermediate Engineering Design L (3)
MAE 491 Experimental Mechanical Engineering L (3)

Total: 6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 111 Macroeconomic Principles SB (3)
ECN 112 Microeconomic Principles SB (3)

Total: 6

MAT 275 Modern Differential Equations MA (3)
MAT 276 Calculus with Analytic Geometry I MA (4)
MAT 277 Calculus with Analytic Geometry II MA (4)
MAT 278 Calculus with Analytic Geometry III MA (4)

Minimum total: 3–6

Mathematical Studies

MAT 205 Calculus with Analytic Geometry I MA (3)
MAT 206 Calculus with Analytic Geometry II MA (4)
MAT 207 Calculus with Analytic Geometry III MA (4)
MAT 208 Calculus with Analytic Geometry IV MA (4)
MAT 303 Linear Algebra MA (3)
MAT 304 Advanced Linear Algebra MA (3)

Minimum total: 3–6

Natural Sciences/Basics Sciences

CHM 114 General Chemistry for Engineers SQ1 (3)
PHY 114 University Physics I: Mechanics SQ1 (3)
PHY 115 University Physics I: Electricity and Magnetism SQ1 (3)
PHY 116 University Physics I: Modern Physics SQ1 (3)

Minimum total: 3

Engineering Core

ECE 100 Introduction to Engineering Design CS (3)
ECE 201 Electrical Networks I (4)
ECE 202 Electrical Networks II (4)
ECE 214 Engineering Mechanics (4)
ECE 313 Introduction to Deformable Solids (3)
ECE 340 Thermodynamics (3)
ECE 350 Structure and Properties of Materials (3)

Total: 20

Mechanical Engineering Major

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 488 Mechanical Engineering Design I (3)
MAE 489 Mechanical Engineering Design II (3)
Computer-aided engineering (three modules) (3–4)

Total: 11–12

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) or higher is required for 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 488 and 489.

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 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 Dynamics and Control (3)
MAE 415 Vibration Analysis (3)
MAE 426 Design of Aerospace Structures (3)
MAE 427 Propulsion (3)
MAE 460 Gas Dynamics (3)
MAE 461 Aerodynamics II (3)
MAE 463 Propulsion (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.

#### Mechanical Engineering Program of Study

#### Typical Four-Year Sequence

**First Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Semester</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHM 114 General Chemistry for Engineers ( S_Q )</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>or CHM 116 General Chemistry ( S_Q ) (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECE 100 Introduction to Engineering Design ( C_S )</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ENG 101 First-Year Composition</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MAT 270 Calculus with Analytic Geometry I ( M_A )</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HU/SB elective</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Second Semester</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENG 102 First-Year Composition</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MAT 271 Calculus with Analytic Geometry II ( M_A )</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MAT 275 Modern Differential Equations ( M_A )</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PHY 121 University Physics I: Mechanics ( S_Q )</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PHY 122 University Physics Laboratory I ( S_Q )</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>HU/SB elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
## DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

### Third Year

#### First Semester
- ECE 300 Intermediate Engineering Design I.....3
- MAE 317 Dynamic Systems and Control.....3
- MAE 319 Measurements and Data Analysis.....3
- MAE 371 Fluid Mechanics.....3
- MAE 394 ST: Computer-Aided Engineering.....1
- MAE 422 Mechanics of Materials.....4

#### Second Semester
- MAE 388 Heat Transfer.....3
- MAE 441 Principles of Design.....3
- HU/SB elective1.....3
- Technical electives.....6

#### Total
- 17

### Fourth Year

#### First Semester
- MAE 488 Mechanical Engineering Design I.....3
- MAE 491 Experimental Mechanical Engineering I.....3
- HU/SB elective1.....6
- Technical electives.....3

#### Second Semester
- MAE 489 Mechanical Engineering Design II.....3
- PHY 361 Introductory Modern Physics.....3
- HU/SB elective3.....3
- Technical electives6.....6

#### Total
- 15

---

1 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to obtain 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.

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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 394 Special Topics. (1–4) 
selected semesters
Topics may include the following:
- Computer-Aided Engineering. (1)

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

MAE 413 Aircraft Dynamics and Control. (3) 
spring
Aircraft static stability; equations of motion; dynamic modes and stability; stability derivatives; response to controls; introduction to automatic control of aircraft. 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

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).

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 453 Computer-Aided Manufacturing and Control. (3)
spring
Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning, and robotics. Cross-listed as IEE 463. Credit is allowed for only IEE 463 or MAE 453. Credit is allowed for only IEE 463 or 543. Fee. Prerequisite: IEE 360 or MAE 351.

General Studies: CS

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 364; MAE 382 (or 460).

MAE 464 Aerospace Laboratory. (3)
fall and spring
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 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)
once a year
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 488 Mechanical Engineering Design I. (3)  
fall and spring  
Conceptual and embodiment design; modeling; rapid prototyping. Team project. MAE 488 and 489 must be taken in consecutive semesters. Lecture, discussion. Prerequisites: MAE 319, 371, 441.  

MAE 489 Mechanical Engineering Design II. (3)  
fall and spring  
Detail design; fabrication and testing. Team project. MAE 488 and 489 must be taken in consecutive semesters. Lecture, discussion. Prerequisite: MAE 488.  

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.  

General Studies: L  
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.  

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.  

PROGRAMS IN ENGINEERING SPECIAL STUDIES  

The BSE 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—BSE  

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 BSE 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 88.  

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 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)
**IRA A. FULTON SCHOOL OF ENGINEERING**

**ENG 108 English for Foreign Students** (3)  
Total ........................................................................................................6

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$^1$ ...........................................3  
  - ECN 112 Microeconomic Principles SB$^1$ (3)  
  - HU/SB and awareness area courses$^2$ ..................................................12  
  Total ........................................................................................................15

* **Literacy and Critical Inquiry**
  - BME 413 Biomedical Instrumentation $L^3$ ............................................3  
  - BME 423 Biomedical Instrumentation Laboratory $L^3$ ..............................1  
  - ECE 300 Intermediate Engineering Design $L$ ............................................3  
  Total ........................................................................................................7

* **Natural Sciences**
  - PHY 121 University Physics I: Mechanics $SQ^4$ .....................................3  
  - PHY 122 University Physics Laboratory I $SQ^4$ ......................................1  
  - PHY 131 University Physics II: Electricity and Magnetism $SQ^5$ ...........3  
  - PHY 132 University Physics Laboratory II $SQ^5$ ......................................1  
  Total ........................................................................................................8

* **Mathematical Studies**
  - ECE 100 Introduction to Engineering Design CS ..................................3  
  - ECE 384 Numerical Methods for Engineers ............................................4  
  - 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  
  Total ........................................................................................................22  

General Studies/school requirements total.............................................52

**Engineering Core**

- ECE 201 Electrical Networks .................................................................4  
- ECE 214 Engineering Mechanics .............................................................4  
- ECE 314 Electronic Circuits .................................................................4  
- ECE 340 Thermodynamics .................................................................3  
- ECE 350 Structure and Properties of Materials .......................................3  
Total ........................................................................................................18

**Engineering Special Studies Program Major—Premedical Engineering Concentration**

- BIO 188 General Biology II $SQ$ .............................................................4  
- BME 101 Introduction to Bioengineering ...............................................3  
- BME 235 Physiology for Engineers ........................................................4  
- BME 318 Biomaterials .............................................................................3  
- BME 331 Biomedical Transport Phenomena ..........................................3  
- BME 350 Signals and Systems for Bioengineers .....................................3  
- BME 417 Biomedical Engineering Capstone Design ................................3  
- BME 470 Microcomputer Applications in Bioengineering ....................4  
- BME 490 Biomedical Engineering Capstone Design ................................3  
- CHM 113 General Chemistry $SQ$ .........................................................4  
- CHM 116 General Chemistry $SQ$ .........................................................4  
- CHM 331 General Organic Chemistry ...............................................3  
- CHM 332 General Organic Chemistry ...............................................3  
- CHM 335 General Organic Chemistry Laboratory ..................................1  
- CHM 336 General Organic Chemistry Laboratory ..................................1

A view of downtown Tempe toward the north features the Brickyard (lower center), home of the Ira A. Fulton School of Engineering; Mill Avenue bridges; and Camelback Mountain in the distance.  

Tim Trumble photo
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CSE 100</td>
<td>Principles of Programming with C++ CS</td>
<td>3</td>
</tr>
<tr>
<td>ECE 380</td>
<td>Probability and Statistics for Engineering Problem Solving CS</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>52</td>
</tr>
</tbody>
</table>

1. ECN 111 or 112 must be included to obtain HU and SB requirements.
2. Engineering students may not use aerospace studies (AES) or military science (MIS) courses to obtain HU or 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. To fulfill medical school admission requirements, premedical students generally should choose BIO 188. Note that BIO 187 General Biology I is required by many medical schools in addition to BIO 188 and the other degree requirements and cannot generally be used as a technical elective.
7. 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++ CS
- ECE 100 Introduction to Engineering Design CS
- ENG 101 First-Year Composition
- MAT 270 Calculus with Analytic Geometry I MA
- Total

### Second Semester
- BME 101 Introduction to Bioengineering
- CHM 113 General Chemistry SQ
- ENG 102 First-Year Composition
- MAT 271 Calculus with Analytic Geometry II MA
- PHY 121 University Physics I: Mechanics SQ
- PHY 122 University Physics Laboratory I SQ
- Total

### Second Year

**First Semester**
- BIO 188 General Biology II SQ
- CHM 116 General Chemistry SQ
- MAT 272 Calculus with Analytic Geometry III MA
- PHY 131 University Physics II: Electricity and Magnetism SQ
- PHY 132 University Physics Laboratory II SQ
- Total

**Second Semester**
- BME 235 Physiology for Engineers
- Total

**Third Year**

### First Semester
- BME 318 Biomaterials
- CHM 331 General Organic Chemistry
- CHM 335 General Organic Chemistry Laboratory
- ECE 214 Engineering Mechanics
- ECE 300 Intermediate Engineering Design L
- ECE 384 Numerical Methods for Engineers
- Total

### Second Semester
- BME 331 Biomedical Transport Phenomena
- BME 350 Signals and Systems for Bioengineers
- CHM 332 General Organic Chemistry
- CHM 336 General Organic Chemistry Laboratory
- ECE 334 Electronic Circuits
- ECE 340 Thermodynamics
- Total

**Fourth Year**

### First Semester
- BME 413 Biomedical Instrumentation L
- BME 417 Biomedical Engineering Capstone Design I
- BME 423 Biomedical Instrumentation Laboratory L
- ECE 380 Probability and Statistics for Engineering Problem Solving CS
- Total

### Second Semester
- BME 570 Microcomputer Applications in Bioengineering
- BME 590 Biomedical Engineering Capstone Design II
- HU/SB and awareness area courses
- Total

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.