Ira A. Fulton School of Engineering

www.fulton.asu.edu

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/studentaffairs/studentlife/judicial/academic_integrity.htm.

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

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 93.

Fulton School Admission Requirements for Freshmen and Transfer Students

Student	Admission Level	Admission Criteria		
Freshmen	Preprofessional	Minimum transfer GPA of 3.00 if any No minimum number of transfer hours No high school math or science deficiency	*and*	Class ranking in upper 25% *or* ABOR GPA of 3.00 minimum *or* ACT minimum combined score of 24 *or* SAT minimum combined math and verbal score of 1140
	Professional	Minimum transfer GPA of 3.50 if any No minimum number of transfer hours No high school math or science deficiency	*and*	ACT minimum combined score of 32 *or* SAT minimum combined math and verbal score of 1400
Transfer students	Preprofessional	Minimum transfer GPA of 3.00 24 transfer hours or more No high school math or science deficiency	*or*	Minimum transfer GPA of 3.00 Less than 24 transfer hours No high school math or science deficiency *and* Class ranking in upper 25% *or* ABOR GPA of 3.00 minimum *or* ACT minimum combined score of 24 *or* SAT minimum combined math and verbal score of 1140

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 certification programs, and graduate degree programs. These online programs allow students with complex schedules to complete advanced work from remote locations. CPD also administers customized programs at company sites. For more information, call 480/965-1740, or access the center's Web site at www.asuengineeringonline.com.

ADMISSION

The Fulton School is home to a number of rigorous professional programs. To help ensure student success in these programs the Fulton School has higher admission requirements than those for the university. High school students are expected to have completed a college preparation curriculum including math through precalculus and at least three years of high school lab science preferably in biology, chemistry, and physics. Transfer students are likewise expected to have performed well in their postsecondary work. 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.

All the programs within the Fulton School are divided into two parts. The freshmen and sophomore years of the program are designated as the preprofessional portion while the junior and senior years are designated as the professional portion. Students in the preprofessional program are only permitted to register for lower-division (100- and 200-level) classes within the school. Promotion from preprofessional to professional status is competitive and not automatic (see "Promotion to Professional Status," page 373).

The following material defines the admission standards for different categories of students.

Direct Admission at the Professional Level. A few high performing freshmen are admitted directly to the professional level. These students will still take the freshmen and sophomore courses but will not have to compete for promotion. If a directly admitted student fails to maintain acceptable academic performance the student may be demoted back to the preprofessional level. Direct admission at the professional level is reserved for freshmen who have completed a college preparation curriculum, have scored 1400 or higher for the sum of the verbal and math portions of the SAT or 32 or higher for the combined ACT, and, if any post secondary transfer work exists, have a transfer GPA of at least 3.50, as shown in the "Fulton School Admission Requirements for Freshmen and Transfer Students" table, on this page.

Freshmen. Most freshmen are admitted to the preprofessional level. Admission to the Fulton School requires high school students to have completed a college preparation curriculum, to have a transfer GPA of 3.00 or higher (if any transfer courses exist) and to satisfy at least one of the high school performance criteria (see "Fulton School Admission Requirements for Freshmen and Transfer Students" table, on this page). Freshmen who are not initially qualified for admittance may still gain admission to the school via the transfer student or change of major route.

Transfer Students. All transfer students are initially admitted to the preprofessional level but some may be eligible to apply for promotion to professional level (see "Promotion to Professional Status," on this page). The admission standards have been set to select students who are ready for one of the professional programs (e.g., demonstrated math and science competency) and who have demonstrated the ability to succeed in a postsecondary environment (at least 24 hours of work with a GPA of 3.00 or higher). Transfer students with less than 24 transfer hours must also satisfy one of the high school performance criteria. Upon admission to one of the school's programs it is highly recommended that transfer students make an appointment to meet with the program's academic advisor to assess their status and develop a plan for success.

International Students. Foreign nationals must meet the same admission requirements shown in the "Fulton School Admission Requirements for Freshmen and Transfer Students" table, page 372 with the possible additional requirement of a minimum TOEFL score. If the university requires a TOEFL score (see "TOEFL," page 73) then admission to the Fulton School requires a minimum TOEFL score of 550 (paper based), 213 (computer based), 79 on iBT (internet based) or a minimum IELTS score of 6.5.

General Education Development. Students admitted to the university after successful completion of the General Education Development examination are admitted as preprofessional students within their major provided they meet the minimum ACT or SAT score required for admission as listed in the"Fulton School Admission Requirements for Freshmen and Transfer Students" table, page 372.

Admission by Change of Major. Students moving into the Fulton School from an ASU program outside of the school are admitted at the preprofessional level. Students who are changing majors must meet the admission standards established for transfer students. Students interested in changing majors are encouraged to make an appointment with an advisor in the program of interest to discuss the probability of success and to develop a plan of action to ensure successful promotion. Change of major is not guaranteed and may be denied based on lack of evidence that the student can successfully complete the program.

Readmission. Students who have been gone from the university for one or more semesters and want to return to the school will need to have a cumulative ASU GPA of 3.00 or higher. Students returning to the same program in Fulton are readmitted to the program at the same level (preprofessional or professional) they had before leaving the school. Students returning to a new program in Fulton are readmitted at the preprofessional level. Returning students who have a cumulative GPA of less than 3.00 may request review by the Office of the Associate Dean of Academic Affairs. As with transfer students it is strongly recommended that each readmitted student consult with an advisor in the program they plan on pursuing to determine the likelihood of being promoted to the professional level.

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.

PROMOTION TO PROFESSIONAL STATUS

Promotion from the preprofessional to the professional level is competitive. All programs within the school use the same general process but the particular requirements are program specific and are listed under each department. Promotion is based on a combination of factors defined by each program but as a minimum consists of the cumulative GPA (ASU and transfer courses if any) for a set of specific courses (referred to as the skill-set). Some programs augment the skill-set criterion with other materials (e.g., a cumulative ASU GPA, essay, exam, etc.). The minimum GPA required for promotion is program specific.

The skill-set for each program has the following characteristics:

1. courses are all lower division (100- and 200-level) courses required by the program for graduation;
2. courses give some prediction of success in the upper-division courses;
3. set includes at least 24 semester hours of course work; and

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 93.

4. courses are all included within the first three semesters of a program as shown in the "Typical Four-Year Sequence" (see departmental material).

Students must apply for promotion and are only permitted to request promotion in the program in which they are currently enrolled. The application period is open for the entire semester and closes with the beginning of final exams. The earliest semester a student can apply for promotion is during the semester they are completing a program's skill-set. A typical promotion sequence would be

1. student completes skill-set during third semester;
2. student applies for promotion during third semester;
3. student enrolls for fourth semester course work during third semester;
4. student's request for promotion is processed during the early part of the fourth semester; and
5. student (if successful) is promoted to professional level and registers for fifth semester (first semester of upper-division Fulton course work).

Students completing some of the skill-set courses at institutions other than ASU will need to have course results transferred to ASU before their application for promotion can be considered.

The skill-set courses for each program can be found in the departmental write-ups or at www.eas.asu.edu/fulton/transfers/professional_programs_general.php.

ADVISING

Successful completion of a program in the Fulton School requires careful planning. While final responsibility for becoming familiar with and understanding academic degree requirements lies with the student, each department employs professional academic advisors who 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 the school's sources of academic support. Students may also work with a faculty advisor familiar with the chosen field of specialization. Students should consult with an advisor before registering each semester.

Earning promotion in a timely manner requires careful planning. Normally promotion requests are made during the third semester and promotion decisions are made during the fourth semester of a typical four-year sequence of classes. This ensures that the student has classes they can take while the promotion decision is being made. All students are encouraged to meet with a program advisor when they are admitted to a program to discuss promotion and how best to proceed.

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.

Advisors and staff in the Office of the Associate Dean for Academic Affairs in the school are available to assist individual students with many different types of advising issues. They 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; hear grade grievances; and assist with other administrative matters. For more information, access the school's Web site at fulton.asu.edu/fulton.

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 advising 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. Generally the special permits are not issued until after grades have been posted (see, "Probation," page 377 for details).

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 74.

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.

Ira A. Fulton School of Engineering Baccalaureate Degrees and Majors

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

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

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

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, on this page. 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 376. 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*.

SCHOOL OF EXTENDED EDUCATION

The university-wide School 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 "School of Extended Education," page 134, or access the Web site at www.asu.edu/xed .

UNIVERSITY GRADUATION REQUIREMENTS

In addition to department and school requirements, students must meet all university graduation requirements (see "University Graduation Requirements," page 89). A well-planned program of study enables students to meet all requirements in a timely fashion. Students are encouraged

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 93.

Ira A. Fulton School of Engineering Graduate Degrees and Majors

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

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

[2] This program is administered by the Division of Graduate Studies.

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 96, 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 89. 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.

ACADEMIC STANDARDS

The school has developed and enforces a number of academic standards, these are designed to support students who are struggling academically and to insure the quality of the school's graduates.

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.

Satisfactory Progress

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 ensure that they get the necessary help. There are many reasons why students fail to make satisfactory progress and meeting with a program academic advisor to work out a program for success is crucial. Students may be required to reduce their course load (13 semester hours maximum), retake courses, or even take courses outside of the program if the advisor judges these measures will help bring the student back to good standing.

Registration for Next Semester Classes. Before students on probation can register for classes in the next semester they must receive advising in their department and then obtain a special permit from an advisor in the Office of the Associate Dean for Academic Affairs. Permits are also required for summer school registration. Generally permits are not issued until final grades for the current semester have been recorded by the registrar but the school may issue the permits immediately following preregistration to some eligible students. Student on probation should check with their department's academic advisor to see if they are eligible for an early permit.

Conditions for Probation. A student is placed on probation when specific academic expectations are not met. Some conditions trigger an automatic placement on probation whereas others trigger an automatic review of the student's case to determine if probation is warranted. When a probation review is triggered, the final decision is made by the student's department, which also determines any conditions of probation.

Automatic probation is triggered by any of the following:

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; and
3. an ASU Cumulative GPA below 2.00 (for more than 55 semester hours).

Automatic review is triggered by any one of the following:

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

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

Disqualification. Students who are on academic probation and fail to meet the school's retention standards become ineligible to continue working toward a degree within the school. Disqualification occurs if the probationary student

1. does not attain a semester GPA of 2.25 or higher; or
2. has a cumulative GPA below 2.00 at the end of the probationary semester; or
3. has been placed on probation for two consecutive semesters.

Students who have been disqualified are subject to the following limitations:

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.

Students who have been disqualified are encouraged to consider these options:

1. They may be eligible to change their major to another college if they have an acceptable cumulative GPA. The acceptable GPA level depends on the number of hours completed course work. Students should check with an advisor in the Office of the Associate Dean of Academic Affairs to determine if they are eligible.
2. They may take nonengineering courses during summer and winter sessions.
3. They 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 this school for at least a 12-month period. Merely having remained in a disqualified status for this period of time does not, in itself, constitute a basis for reinstatement. Proof of ability to do satisfactory college work in the chosen discipline is required, for example, completing at least 15 semester hours of pertinent courses in the discipline at a community college with a GPA of 3.00 or higher, and a cumulative GPA of 2.50 or higher for all courses completed.

SPECIAL PROGRAMS

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 BS or BSE degree. Interested students should contact their major department for details.

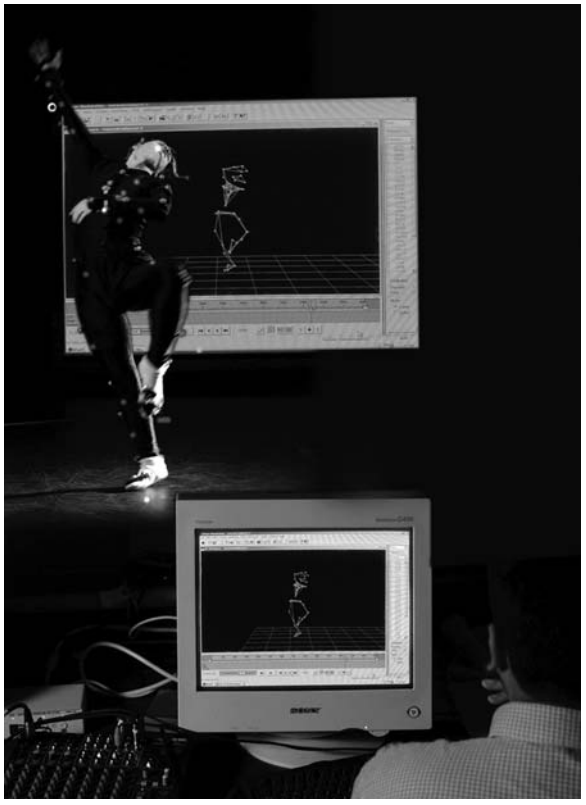
Undergraduate Research. The Fulton Undergraduate Research Initiative (FURI) program allows undergraduate students to participate in university-level research. Students, in collaboration with mentors, make proposals to FURI to fund the research work they want to perform. Students are eligible to apply after only one semester of work. Projects range from one semester to several years. A research poster symposium is held each semester to present the results of

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 93.

the research. For more information, access the school's Web site at eas.asu.edu/fulton/departments/furi/index.php.

Certificate Program in Technology Entrepreneurship. Engineers and scientists around the globe launch high-tech companies to move their ideas to the market. Studies show that the majority of innovative products and services in the economy evolve from entrepreneurial ventures. By providing knowledge and skills important to the creation and leadership of such startups, the certificate program in Technology Entrepreneurship aims to train the founders and leaders of tomorrow's high-tech ventures. The certificate program is designed specifically for engineers. Courses are approached from the perspective of the student whose primary interest is in technological innovation, whose primary concentration is on engineering, and who has little or no prior business education. For more information, call 480/965-9480.

Science Math Engineering Competition Awards (SMECA) Scholarships. The school has a limited number of scholarships available to students who competed during high school in regional or national science, mathematics or engineering competitions (e.g., National Science Fair, FIRST). The scholarship is renewable up to five years. Interested students should access the school's Web site at www.fulton.asu.edu/fulton/students/sas/scholarships.php for details.



The Arts, Media, and Engineering program is offered collaboratively by the Katherine K. Herberger College of Fine Arts and the Ira A. Fulton School of Engineering.

Tim Trumble photo

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 by invitation; students winning a SMECA scholarship receive automatic membership.

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/sa/fa_website.

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.

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 FSE 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 145.

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 fulton.asu.edu/fulton/students/sas/scholarships.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.

Del E. Webb School of Construction

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

James J. Ernzen, Interim Director

Professors: Badger, Kashiwagi

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

Assistant Professors: Fiori, Mitropoulos, Sullivan

Senior Lecturer: Knutson

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 sciences courses on which students may build defined concentrations to suit individual backgrounds, aptitudes, and objectives. These

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 93.

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, the Construction Women's Alliance, and the Mechanical Contractors Association of America.

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 372; and "Degree Requirements," page 381. Students applying to the program will be admitted to either the professional or preprofessional category depending upon their qualifications. For more information about the Fulton School of Engineering, see "Admission," page 372.

Vocational and craft-oriented courses taught at community colleges are not accepted for credit toward a bachelor's degree in Construction.

The Preprofessional Program. Each student admitted to the Del E. Webb School of Construction preprofessional program will follow the freshman and sophomore sequence of courses listed in the section "Typical First Two Year Course Sequence," page 382. Students should follow the recommendations of their staff and faculty academic advisors in completing the prescribed background and skill courses in preparation for passage to the professional program. The skill courses are

COM	225	Public Speaking *L*	3
CON	221	Applied Engineering Mechanics: Statics	3
CON	243	Heavy Construction Equipment, Methods, and Materials	3
CON	251	Microcomputer Applications for Construction	3
CON	252	Building Construction Methods, Materials, and Equipment	3
ECN	212	Microeconomic Principles *SB*	3
ENG	102	First-Year Composition	3
MAT	294	ST: Calculus for Engineers I	3
PHY	111	General Physics *SQ**	3
PHY	113	General Physics Laboratory *SQ**	1
STP	226	Elements of Statistics *CS*	3
Total			31

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

The Professional Program. The junior and senior years constitute the professional program of the undergraduate curriculum. Admission to the professional program is competitive and limited by available resources. Admission is awarded to those applicants demonstrating the highest promise for professional success. The admissions committee considers overall transfer GPA and ASU GPA as well as grades achieved in the skill courses listed above. Students seeking professional status must have completed all of the skill courses before applying. Students who wish to apply to the Del E. Webb School of Construction professional program must submit an application during one of the three annual application periods. Candidates are strongly encouraged to visit with their faculty and staff academic advisors at the beginning of the semester in which they wish to apply to obtain information regarding academic qualifications, admissions criteria, and application deadlines. The application form can be found on the department's Web site at construction.asu.edu. All applicants must be admitted to ASU by the time they submit their professional program application and must provide official SAT or ACT scores and must have completed all the skill-set classes.

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 89) 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. Participation in a summer management internship is required for all students between the third and fourth year 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 120 semester hours with at least 45 hours at the upper-division level is required for graduation from the program. 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 93, and all university graduation requirements as noted in "University Graduation Requirements," page 89. Note that all three General Studies awareness areas are required. Consult an advisor for an approved list of courses.

SCHOOL COURSE REQUIREMENTS

First Year Composition Requirements[1]

Choose one of the following combinations 6
- ENG 101 First-Year Composition (3)
- ENG 102 First-Year Composition[2] (3)

——— *or* ———

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

——— *or* ———

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

First year composition total 6

General Studies[3]

Humanities and Fine Arts/Social and Behavioral Sciences

CON 101 Construction and Culture: A Built Environment *HU, G, H* 3
ECN 211 Macroeconomic Principles *SB* 3
ECN 212 Microeconomic Principles *SB*[2] 3
HU/SB and awareness area course 3
HU/SB (upper division) and awareness area course 3

HU/SB awareness area subtotal 15

Literacy and Critical Inquiry

COM 225 Public Speaking *L*[2] 3
CON 496 Construction Contract Administration *L* 3

L, C awareness subtotal 6

Natural Sciences

PHY 111 General Physics *SQ*[2, 4] 3
PHY 113 General Physics Laboratory *SQ*[2, 4] 1
Physical science elective *SQ*/*SG* 4

SQ awareness subtotal 8

Mathematical Studies

MAT 294 ST: Calculus for Engineers I[2] 3
STP 226 Elements of Statistics *CS*[2] 3

MA, CS awareness subtotal 6

General Studies/school requirements total 35

Courses in Major Requirements Common to All Concentrations

ACC 394 ST: Financial Analysis and Accounting for Small Businesses 3
CON 221 Applied Engineering Mechanics: Statics[2] 3
CON 223 Strength of Materials 3
CON 241 Surveying 3
CON 243 Heavy Construction Equipment, Methods, and Materials[2] 3
CON 251 Microcomputer Applications for Construction[2] 3
CON 252 Building Construction Methods, Materials, and Equipment[2] 3
CON 296 Field Internship 1
CON 371 Construction Management and Safety 3
CON 383 Construction Estimating 4
CON 389 Construction Cost Accounting and Control *CS* 3
CON 394 ST: Biological Considerations in Construction 1
CON 424 Structural Design 3
CON 450 Geotechnical Applications for Construction 3
CON 453 Construction Labor Management 3
CON 455 Construction Project Management 3
CON 484 Managerial Internship 1
CON 495 Construction Planning and Scheduling *CS* 3
LES 305 Legal, Ethical, and Regulatory Issues in Business 3

Courses in common requirements subtotal 52

Concentration requirements subtotal[5] 27
Major total 79

Program total 120

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

2 This is a skill-set course.

3 Students are encouraged to select HU/SB courses to complement their technical program. For more information, see "General Studies," page 93.

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

5 For details on concentration requirements, see "Concentrations," on this page.

Concentrations

There are four concentrations available in construction, the course requirements are given below.

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 93.

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

Requirements

CON	194	ST: Introduction to Construction	1
CON	273	Electrical Construction Fundamentals	3
CON	310	Testing of Materials for Construction	3
CON	345	Mechanical Systems	3
CON	472	Development Feasibility Reports *L*	3
CON	483	Advanced Building Estimating	3
CON	494	ST: Leadership, Management, and Entrepreneurship in Construction	2
PUP	432	Planning and Development Control Law	3
REA	380	Real Estate Fundamentals	3
Upper-division elective			3
Total			27

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

CON	194	ST: Introduction to Construction	1
CON	273	Electrical Construction Fundamentals	3
CON	310	Testing of Materials for Construction	3
CON	345	Mechanical Systems	3
CON	486	Heavy Construction Estimating	3
CON	494	ST: Heavy Construction Project Management	3
CON	494	ST: Leadership, Management, and Entrepreneurship in Construction	2
Upper-division electives			9
Total			27

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

Requirements

CON	194	ST: Introduction to Construction	1
CON	273	Electrical Construction Fundamentals	3
CON	310	Testing of Materials for Construction	3
CON	345	Mechanical Systems	3
CON	377	Residential Construction Production Procedures	3
CON	477	Residential Construction Business Practices	3
CON	494	ST: Leadership, Management, and Entrepreneurship in Construction	2
MKT	382	Advertising and Marketing Communication	3
PUP	432	Planning and Development Control Law	3
REA	380	Real Estate Fundamentals	3
Total			27

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

Requirements

CON	194	ST: Introduction to Construction	1
CON	273	Electrical Construction Fundamentals	3
CON	310	Testing of Materials for Construction	3
CON	345	Mechanical Systems	3
CON	468	Mechanical and Electrical Estimating	3
CON	471	Mechanical and Electrical Project Management	3
CON	494	ST: Cleanroom Construction	3
CON	494	ST: Leadership, Management, and Entrepreneurship in Construction	2
Upper-division electives			6
Total			27

Typical First Two Year Course Sequence

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 120 semester hours required for the degree. The course work for the first two years is similar for all concentrations.

First Semester

CON	101	Construction and Culture: A Built Environment *HU, G, H*	3
CON	194	ST: Introduction to Construction	1
ECN	211	Macroeconomic Principles *SB*	3
ENG	101	First-Year Composition	3
MAT	294	ST: Calculus for Engineers I	3
PHY	111	General Physics *SQ*[1]	3
PHY	113	General Physics Laboratory *SQ*[1]	1
Total			17

Second Semester

COM	225	Public Speaking *L*	3
CON	252	Building Construction Methods, Materials, and Equipment	3
ECN	212	Microeconomic Principles *SB*	3
ENG	102	First-Year Composition	3
HU/SB and awareness area course			3
Total			15

Third Semester

CON	221	Applied Engineering Mechanics: Statics	3
CON	243	Heavy Construction Equipment, Methods, and Materials	3
CON	251	Microcomputer Applications for Construction	3
CON	273	Electrical Construction Fundamentals	3
STP	226	Elements of Statistics *CS*	3
Total			15

Fourth Semester

CON	223	Strength of Materials	3
CON	241	Surveying	3
Construction elective from concentration			3
HU/SB and awareness area course			3
SQ elective with lab[2]			4
Total			16

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

[2] Physical science elective with lab required to secure SQ credit.

CONSTRUCTION (CON)

M CON 101 Construction and Culture: A Built Environment. (3)
fall and spring
Analyzes the cultural context of construction, emphasizing its centrality in the evolution and expansion of built environments as expressions of ethical and historical value systems. Lecture, speakers.
General Studies: HU, G, H

M CON 194 Special Topics. (1–4)
selected semesters
Topics may include the following:
- Introduction to Construction. (1)

M CON 221 Applied Engineering Mechanics: Statics. (3)
fall and spring
Vectors, forces and moments, force systems, equilibrium, analysis of basic structures and structural components, friction, centroids, and moments of inertia. Prerequisites: MAT 270 (or 294 ST: Calculus for Engineers I); PHY 111, 113.

M CON 223 Strength of Materials. (3)
fall and spring
Analyzes strength and rigidity of structural members in resisting applied forces. Stress, strain, shear, moment, deflections, combined stresses, and connections. Both U.S. and SI units of measurement. Prerequisite: CON 221.

M CON 241 Surveying. (3)
fall, spring, summer
Theory and field work in construction and land surveys. Cross-listed as CEE 281. Credit is allowed for only CEE 281 or CON 241. Fee. Lecture, lab. Prerequisite: MAT 270 (or 294 ST: Calculus for Engineers I).

M CON 243 Heavy Construction Equipment, Methods, and Materials. (3)
fall and spring
Emphasizes "Horizontal" construction. Fleet operations, maintenance programs, methods, and procedures to construct tunnels, roads, dams, and the excavation of buildings. Lab, field trips. Fee.

M CON 251 Microcomputer Applications for Construction. (3)
fall and spring
Applies the microcomputer as a problem-solving tool for the constructor. Uses spreadsheets, information management, and multimedia software. Lab. Fee.

M CON 252 Building Construction Methods, Materials, and Equipment. (3)
fall and spring
Emphasizes "Vertical" construction. Methods, materials, codes, and equipment used in building construction corresponding to the 16 division "Master Format."

M CON 273 Electrical Construction Fundamentals. (3)
fall and spring
Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Lecture, field trips.

M CON 296 Field Internship. (1)
summer
Participation as interns on construction projects to observe and experience the daily activities. Internship. Fee.

M CON 310 Testing of Materials for Construction. (3)
fall and spring
Structural and behavioral characteristics, engineering properties, measurements, and application of construction materials. Not open to engineering students. Lecture, lab. Fee. Prerequisite: CON 223.

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

M CON 371 Construction Management and Safety. (3)
fall and spring
Organization and management theory applied to the construction process. Leadership functions. Safety procedures and equipment. OSHA requirements for construction. Prerequisite: CON 252.

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

M CON 383 Construction Estimating. (4)
fall and spring
Analyzes construction drawings and specifications. Methods used in estimating process. Quantity surveying techniques for CSI divisions. Lecture, project workshops. Prerequisites: CON 243, 252.

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

M CON 394 Special Topics. (1–4)
fall and spring
Topics may include the following:
- Biological Considerations in Construction
- Gender, Race, Class in the Construction Industry Workforce
- Megaprojects: Their Impacts on Society

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

M CON 450 Geotechnical Applications for Construction. (3)
fall and spring
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.

M CON 453 Construction Labor Management. (3)
fall and spring
Labor and management history, union, and open shop organization of building and construction workers; applicable laws and government regulations; goals, economic power, jurisdictional disputes, and grievance procedures. Prerequisites: CON 371; ECN 212.

M CON 455 Construction Project Management. (3)
fall and spring
Study of methods for coordinating people, equipment, materials, money, and schedule to complete a project on time and within approved cost. Lecture, class projects, CPC exam. Fee. Prerequisite: CON 371. Pre- or corequisite: CON 495.

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

M CON 471 Mechanical and Electrical Project Management. (3)
spring
Specialty contracts and agreements, scheduling, material handling, labor unit analysis, and job costing for mechanical and electrical construction. Prerequisite: CON 371.

M CON 472 Development Feasibility Reports. (3)
fall and spring
Integrates economic location theory, development cost data, market research data, and financial analysis into a feasibility report. Computer orientation. Prerequisite: REA 380.
General Studies: L

M CON 477 Residential Construction Business Practices. (3)
spring
Topics addressed include development, marketing, financing, legal issues, and sales. Prerequisites: CON 389; MKT 382.

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 93.

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

M 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.

M CON 486 Heavy Construction Estimating. (3)
fall
Methods analysis and cost estimation for construction of highways, bridges, tunnels, dams, and other engineering works. Lecture, field trips. Prerequisites: CON 241, 383.

M CON 492 Honors Directed Study. (1–6)
selected semesters

M CON 493 Honors Thesis. (1–6)
selected semesters

M CON 494 Special Topics. (1–4)
fall and spring
Topics may include the following:
- Cleanroom Construction. (3)
  fall
- Heavy Construction Project Management. (3)
- Leadership, Management, and Entrepreneurship in Construction. (2)

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

M CON 496 Construction Contract Administration. (3)
fall and spring
Surveys administrative procedures of general and subcontractors. Studies documentation, claims, arbitration, litigation, bonding, insurance, and indemnification. Discusses ethical practices. Lecture, field trips. Prerequisites: COM 225; senior standing.
General Studies: L

M 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/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.

Engineering Programs

480/965-1726

PURPOSE

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

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

1. those who wish to pursue a career in engineering;
2. those who wish to do graduate work in engineering;
3. those who plan to pursue a nonengineering career but want the technical background associated with a BS or BSE; and
4. those who wish to take certain electives in engineering while pursuing another program in the university.

ADMISSION

All engineering and computer science programs are divided into two parts: a preprofessional program and a professional program. Students are generally admitted into one of the preprofessional programs. For information regarding requirements for admission, transfer, retention, disqualification, and reinstatement in the Fulton School of Engineering, see “Admission,” page 372 and “Academic Standards,” page 376. For information regarding the professional programs see ““Promotion to Professional Status,” page 373 or departmental material.

Students who are beginning their initial college work in engineering should have completed a rigorous university preparation curriculum in secondary school. Such a curriculum would generally consist of four years of English; four years of mathematics through at least precalculus, including a course with trigonometry; and three years of lab science, including chemistry and physics. Biology, calculus, and computer programming are recommended. Students who do not meet subject matter requirements may be required to complete additional university course work to meet the prerequisites for required courses. One or more of the following courses may be required to satisfy omissions or deficiencies upon admission: CHM 113 General Chemistry, CSE 180 Computer Literacy, CSE 181 Applied Problem Solving with Visual BASIC, MAT 170 Precalculus, and PHY 105 Basic Physics.

DEGREES

The Bachelor of Science in Engineering (BSE) degree and the BS degree in Computer Science consist 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, fine arts and design; social and behavioral sciences; mathematical studies; and natural sciences (see “General Studies,” page 93). 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 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). 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 and computer science study are the preprofessional years and are intended to develop the foundation upon which the professional program is built. The preprofessional courses include a number of the university general studies courses as well as the skill-set courses that are used to help determine if a student can be promoted to the professional program. The final two years of the program are the professional years during which depth and breadth in the major is achieved.

The semester-by-semester selection of courses varies from one field to another and is determined by the student in consultation with a faculty or professional advisor. See the "Typical Four-Year Sequence" tables in each of the department sections of this catalog for example courses for a full-time student.

Well-prepared students who have no outside commitments can usually complete the program of study leading to an undergraduate degree in engineering in four years (eight semesters at 15 semester hours per semester). Many students, however, find it advantageous or necessary to devote more than four years to the undergraduate program by pursuing, in any semester, fewer courses than are regularly prescribed. Where omissions or deficiencies exist—e.g., in chemistry, computer programming, English, mathematics, and physics—the student must complete more than the minimum of 120 semester hours. Therefore, in cases of inadequate secondary preparation, poor health, or financial necessity requiring considerable time for outside work, the undergraduate program is extended beyond four years.

DEGREE REQUIREMENTS

The degree programs in engineering and computer science 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 89), and the literacy and critical inquiry component (see "Five Core Areas," page 93) 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. *Fulton requirements*. To help ensure its students achieve the school's aspirations for its graduates (see "The Fulton Aspirations," page 371) all engineering programs are required to have an Introduction to Engineering course; a course with significant biological content, and a course that exposes students to current business practice. Each program uses a different selection of courses that are scattered throughout the four years. In addition to these three specific courses, the programs have included leadership development modules within some of their courses.
4. *Specific engineering discipline*. This area provides a depth of understanding of a 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

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 93.

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.

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
111 MARKET PLACE, SUITE 1050
BALTIMORE MD 21202-4012

The commission may be called at 410/347-7700.

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

FULTON SCHOOL OF ENGINEERING (FSE)

M FSE 105 College Adjustment and Survival. (1)
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.

M FSE 194 Special Topics. (1–4)
fall
Topics may include the following:
- MEP Academic Success. (2)

M FSE 200 Elements of Engineering Design. (3)
fall and spring
Advanced version of introduction to engineering for students who have not taken an introduction to engineering course. Credit is allowed for only FSE 200 or various program introduction to engineering courses. Lecture, lab. Prerequisites: ENG 101 (or 105); MAT 270 (or 294 ST: Calculus for Engineers I); PHY 121, 122. Pre- or corequisite: CHM 113 or 114 or 116.
General Studies: CS

M FSE 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.

M FSE 494 Special Topics. (1–4)
fall

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

Harrington Department of Bioengineering

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

Eric J. Guilbeau, Chair

CORE FACULTY

Olin Endowed Professor: Guilbeau
Professors: Akay, Garcia, He, Towe
Associate Professors: Abbas, Iasemidis, Joshi, Jung, Massia, Pizziconi, Steinmetz
Assistant Professors: Buneo, Caplan, Helms-Tillery, Muthuswamy, Vernon
Research Professors: Brophy, Herman, Panitch
Assistant Research Professors: Furnish, Shimansky
Senior Research Professional: Brandon
Research Scientists: Ehteshami, Pauken
Assistant Research Scientist: La Belle
Senior Lecturer: Coursen

AFFILIATED FACULTY

Electrical Engineering
Professor: Kozicki

Electronics and Computer Engineering Technology (Polytechnic Campus)
Associate Professor: Macia

Kinesiology
Associate Professor: Santello
Assistant Professor: Dounskaia

The faculty in the Harrington Department of Bioengineering offer the BSE degree in Bioengineering. The major builds on a broad base of knowledge in mathematics and science. 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 434.

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*.

ADMISSION REQUIREMENTS

The Preprofessional Program. All students admitted to the Harrington Department of Bioengineering are granted preprofessional status. During the time students are in the preprofessional program, they will follow the sequence of first- and second-year courses shown in the Typical Four Year Sequence for bioengineering students. Promotion from the preprofessional program to the professional program is not automatic and a separate application procedure is required.

Promotion is based on performance in a collection of skill-set courses all of which are included in the typical first three semesters of the program. The skill-set courses are as follows:

Skill Courses

BME 100 Introduction to Bioengineering *CS* 3
Choose one of the following combinations 4
BME 111 Engineering Perspectives on Biological Systems (3)
BME 194 ST: Biology for Engineering Laboratory (1)
——— *or* ———
BIO 188 General Biology II[1] *SQ* (4)
BME 294 ST: Conservation Principles in Bioengineering 3
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[2] (4)
MAT 294 ST: Calculus for Engineers I 3
MAT 294 ST: Calculus for Engineers II 3
MAT 294 ST: Calculus for Engineers III 3
PHY 121 University Physics I: Mechanics *SQ*[3] 3
PHY 122 University Physics Laboratory I *SQ*[3] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[4] 3
PHY 132 University Physics Laboratory II *SQ*[4] 1
Total 31

[1] To fulfill medical school admission requirements, premedical students should choose BIO 188. Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.

[2] To fulfill medical school admission requirements, premedical students generally should choose CHM 116. Note that CHM 113 is required by many medical schools in addition to CHM 116. CHM 113 cannot be used for degree 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.

The Professional Program. Admission to the professional program is competitive. All students seeking admission to the professional program must follow the application procedure described in the Harrington Department of Bioengineering Web site. Admission is granted to those applicants who have demonstrated high promise for professional success. Transfer students who have completed the equivalent required lower-division skill-set courses may also apply to the professional program. While only students who have been admitted to the Bioengineering program are eligible to apply to the professional program, prior attendance at ASU is not required. Completion of the specified preprofessional course work does not guarantee admission to the professional program.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Bioengineering. A minimum of 45 upper-division semester hours is required. Students must attain a GPA of at least 2.00 for upper-division courses in the major.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 89.

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

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 93.

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)

First-year composition total 6

General Studies/Program Requirements

Humanities and Fine Arts/Social and Behavioral Sciences
HU/SB and awareness area courses 15

HU/SB and awareness area courses subtotal 15

Literacy and Critical Inquiry
Six semester hours of literacy and critical inquiry credit is satisfied by course work in the major.

Natural Sciences/Basic Sciences
Choose one of the following combinations 4
BME 111 Engineering Perspectives on Biological Systems (3)
BME 194 ST: Biology for Engineering Laboratory (1)
——— *or* ———
BIO 188 General Biology II *SQ*[1] (4)
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[2] (4)
Choose one of the following course groups 4
CHM 231 Elementary Organic Chemistry *SQ*[3] (3)
CHM 235 Elementary Organic Chemistry Laboratory *SQ*[3] (1)
——— *or* ———
CHM 233 General Organic Chemistry I[4, 5] (3)
CHM 237 General Organic Chemistry Laboratory I[4, 5] (1)
PHY 121 University Physics I: Mechanics *SQ*[6] 3
PHY 122 University Physics Laboratory I *SQ*[6] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[7] 3
PHY 132 University Physics Laboratory II *SQ*[7] 1

Natural sciences/basic sciences subtotal 20

Mathematical Studies
CSE 100 Principles of Programming with C++ CS 3
MAT 275 Modern Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers I 3
MAT 294 ST: Calculus for Engineers II 3
MAT 294 ST: Calculus for Engineers III 3
MAT 343 Applied Linear Algebra 3

Mathematical studies subtotal 18

General Studies/school requirements total 53

Lower-Division Engineering Courses
BME 100 Introduction to Bioengineering *CS* 3
BME 235 Physiology for Engineers 4
BME 294 ST: Conservation Principles in Bioengineering 3
EEE 202 Circuits I 4
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAE 212 Engineering Mechanics 4

Lower-division courses total 21

Upper-Division Courses in Major
BME 300 Bioengineering Product Design 3
BME 318 Biomaterials 4
BME 331 Bioengineering Transport Phenomena 3
BME 350 Signals and Systems for Bioengineers 3
BME 370 Microcomputer Applications in Bioengineering 3
BME 413 Biomedical Instrumentation *L*[8] 3
BME 417 Biomedical Engineering Capstone Design I 4
BME 423 Biomedical Instrumentation Laboratory *L*[8] 1
BME 434 Applications of Bioengineering Transport Phenomena 3
or BME 416 Biomechanics (3)
or BME 419 Biocontrol Systems (3)
BME 490 Biomedical Engineering Capstone Design II 4
CHM 341 Elementary Physical Chemistry 3
Technical electives 6

Upper-division course total 40

Program total 120

---

1 To fulfill medical school admission requirements, premedical students generally should choose BIO 188. Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.

2 To fulfill medical school admission requirements, premedical students generally should choose CHM 116. Note that CHM 113 is required by many medical schools in addition to CHM 116. CHM 113 cannot be used for degree credit.

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

4 To fulfill medical school admission requirements, premedical students generally should choose CHM 233/237. Note that CHM 234/238 are required by many medical schools in addition to CHM 233/237.

5 If CHM 233/237 are taken to satisfy the natural science requirement, these courses are not eligible to be applied as technical electives.

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

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

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

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 major sequence course:

BME 434 Applications of Bioengineering Transport Phenomena 3

Students should choose 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
CHM 234 General Organic Chemistry II 3

CHM 238 General Organic Chemistry Laboratory II 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 must take the following major sequence course:

BME 419 Biocontrol Systems 3

Students should choose technical electives from the following:

EEE 203 Signals and Systems I 3
EEE 230 Computer Organization and Assembly Language Programming 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 major sequence course:

BME 434 Applications of Bioengineering Transport Phenomena 3

Students should choose technical electives from the following:

BME 494 ST: Biopolymeric Drug Delivery 3
MSE 353 Introduction to Materials Processing and Synthesis 3
MSE 355 Materials Structure and Microstructure 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 major sequence course:

BME 416 Biomechanics 3

Recommended subarea selections are as follows:

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

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

Orthopaedic Biomechanics
KIN 412 Biomechanics of the Skeletal System 3
MAE 404 Finite Elements in Engineering 3

* This course may be applied as a technical elective if not already taken as the major sequence course.

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 must take the following major sequence course:

BME 419 Biocontrol Systems 3

Students should choose technical electives from the following:

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

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

BME 419 Biocontrol Systems 3

Students should choose technical electives from the following:

BME 434 Applications of Bioengineering Transport Phenomena* 3
EEE 480 Feedback Systems 4
MAE 318 Sensors and Controls 5
MAE 404 Finite Elements in Engineering 3
MAE 417 Control System Design 3

* This course may be applied as a technical elective if not already taken as the major sequence course.

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 must take the following major sequence course:

BME 434 Applications of Bioengineering Transport Phenomena 3

Students should choose 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)
BIO 353 Cell Biology 3
BME 451 Cell Biotechnology Laboratory 3
BME 494 ST: Introduction to Molecular, Cellular, and Tissue Engineering 3
CHE 475 Biochemical Engineering 3

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

CHM 234 General Organic Chemistry II 3
CHM 238 General Organic Chemistry Laboratory II 1

Students should choose one major sequence course from the following:

BME 416 Biomechanics* 3
BME 419 Biocontrol Systems* 3
BME 434 Applications of Bioengineering Transport Phenomena* 3
BME 494 ST: Biopolymeric Drug Delivery 3
BME 494 ST: Introduction to Molecular, Cellular, and Tissue Engineering 3

* This course may be applied as a technical elective if not already taken as the major sequence course.

Note: 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
BME 100 Introduction to Bioengineering *CS* 3
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[1] (4)
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
Total 13

Second Semester
ENG 102 First-Year Composition 3
Choose from one of the following groups 4
BME 111 Engineering Perspectives on Biological Systems (3)
BME 194 ST: Biology for Engineering Laboratory (1)
——— *or* ———
BIO 188 General Biology II *SQ*[2] (4)
MAT 294 ST: Calculus for Engineers II 3
PHY 121 University Physics I: Mechanics *SQ*[3] 3
PHY 122 University Physics Laboratory I *SQ*[3] 1
Total 14

Second Year

First Semester
BME 294 ST: Conservation Principles in Bioengineering 3
Choose from one of the following groups 4
CHM 231 Elementary Organic Chemistry *SQ*[4] (3)
CHM 235 Elementary Organic Chemistry Laboratory *SQ*[4] (1)
——— *or* ———
CHM 233 General Organic Chemistry I[5, 6] (3)
CHM 237 General Organic Chemistry Laboratory I[5, 6] (1)
CSE 100 Principles of Programming with C++ *CS* 3
MAT 294 ST: Calculus for Engineers III 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[7] 3
PHY 132 University Physics II Laboratory *SQ*[7] 1
Total 17

Second Semester
BME 235 Physiology for Engineers 4
EEE 202 Circuits I 4
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAT 275 Modern Differential Equations *MA* 3
HU/SB and awareness area course[8] 3
Total 17

Third Year

First Semester
BME 318 Biomaterials 4
CHM 341 Elementary Physical Chemistry 3
MAE 212 Engineering Mechanics 4
MAT 343 Applied Linear Algebra 3
HU/SB and awareness area[8] 3
Total 17

Second Semester
BME 300 Bioengineering Product Design 3
BME 331 Bioengineering Transport Phenomena 3
BME 350 Signals and Systems for Bioengineers 3
BME 370 Microcomputer Applications in Bioengineering 3
HU/SB and awareness area course[8] 3
Total 15

Fourth Year

First Semester

BME 413	Biomedical Instrumentation *L*[9]	3
BME 417	Biomedical Engineering Capstone Design I	4
BME 423	Biomedical Instrumentation Laboratory *L*[9]	1
BME 434	Applications of Bioengineering Transport Phenomena or BME 416 Biomechanics (3) or BME 419 Biocontrol Systems (3)	3
HU/SB and awareness area course[8]		3
Total		14

Second Semester

BME 490	Biomedical Engineering Capstone Design II	4
HU/SB awareness area[8]		3
Technical electives		6
Total		13

Total degree requirements 120

1 To fulfill medical school admission requirements, premedical students generally should choose CHM 116. Note that CHM 113 is required by many medical schools in addition to CHM 116. CHM 113 cannot be used for degree credit.

2 To fulfill medical school admission requirements, premedical students generally should choose BIO 188. Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.

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

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

5 To fulfill medical school admission requirements, premedical students generally should choose CHM 233/237. Note that CHM 234/238 are required by many medical schools in addition to CHM 233/237.

6 If CHM 233/237 are taken to satisfy the natural science requirement, these courses are not eligible to be applied as technical electives.

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

8 Engineering students may not use Aerospace Studies (AES) or Military Science (MIS) courses to fulfill HU or SB requirements.

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

BIOENGINEERING (BME)

M BME 100 Introduction to Bioengineering. (3)
fall and spring
Introduces profession of bioengineering: bioengineering design process, teaming, computer models in bioengineering, communications skills, career planning. Fee. Prerequisites: high school computing and physics and algebra courses (or their equivalents); BME major (or department approval). Pre- or corequisite: ENG 101 or 105 or 107.
General Studies: CS

M BME 101 Introduction to Bioengineering. (3)
fall and spring
Impact of bioengineering on society. Develops an awareness of the contributions of bioengineering to solve medical and biological problems. Fee. Pre- or corequisites: ENG 102 (or 105 or 108); BME major (or department approval).

M BME 111 Engineering Perspectives on Biological Systems. (3)
fall and spring
Biological concepts for the emerging engineer. Introduces biological and earth systems engineering, materials, structures, fluid mechanics, bioelectricity, and the dynamic, nonlinear nature of nature.

M BME 112 Engineering Perspectives on Biological Systems Laboratory. (1)
fall and spring
Introduces biological concepts for the emerging engineer in a lab setting: biological and earth systems engineering, materials, structures, fluid mechanics, bioelectricity, and the dynamic, nonlinear nature of nature. Lab. Prerequisite: BME 111.

M BME 194 Special Topics. (1–4)
selected semesters
Topics may include the following:
- Biology for Engineering Lab.oratory. (1)

M BME 200 Conservation Principles in Bioengineering. (3)
fall and spring
Applies bioengineering analysis and problem solving of mass, energy, and charge balances to medical and biological systems. Prerequisite: CHM 114 or 116. Pre- or corequisites: PHY 131, 132.

M 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: ECN 211 (or 212); ENG 102 (or 105).
General Studies: L/HU

M BME 235 Physiology for Engineers. (4)
fall 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.

M BME 294 Special Topics. (1–4)
selected semesters
Topics may include the following:
- Conservation Principles in Bioengineering. (3)

M BME 300 Bioengineering Product Design. (3)
fall and spring
The fundamentals of financial and organizational structure of business and how it influences bioengineering analysis, design, and decision making; biomedical ethics and device and drug regulation; and fundamentals of business and technical management. Prerequisites: BME 100; ENG 102 (or 105 or 108); junior standing.

M BME 318 Biomaterials. (4)
fall and spring
Material properties of natural and artificial biomaterials. Tissue and blood biocompatibility. Uses of materials to replace body parts. Prerequisite with a grade of "C" (2.00) or higher: BME 235.

M BME 331 Bioengineering Transport Phenomena. (3)
fall and spring
Transport phenomena with emphasis on momentum, energy, and mass transport in living systems, medical devices, and other therapeutic/diagnostic applications. Prerequisites: CHM 341; MAE 212; MAT 274 (or 275).

M BME 350 Signals and Systems for Bioengineers. (3)
fall and spring
Applies principles of calculus and ordinary differential equations to analysis and computer processing of biosignals and linear modeling of biosystems. Prerequisites: EEE 202; MAT 274 (or 275). Pre- or corequisite: MAT 343.

M BME 370 Microcomputer Applications in Bioengineering. (3)
fall and spring
Uses microcomputers for real-time data collection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Fee. Prerequisite with a grade of "C" (2.00) or higher: BME 235, 350.

M 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.

M 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.

M BME 413 Biomedical Instrumentation. (3)
fall and spring
Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems. Prerequisites with a grade of "C" (2.00) or higher: BME 235. 350. Corequisite: BME 423.
General Studies: L (if credit also earned in BME 423)

M 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.

M BME 416 Biomechanics. (3)
fall
Mechanical properties of bone, muscle, and soft tissue. Static and dynamic analysis of human movement tasks such as locomotion. Prerequisite: MAE 212. Prerequisite with a grade of "C" (2.00) or higher: BME 318.

M BME 417 Biomedical Engineering Capstone Design I. (4)
fall
Technical, regulatory, economic, legal, social, and ethical aspects of medical device systems engineering design. Lecture, field trips. Prerequisite with a grade of "C" (2.00) or higher: BME 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, 370, 413; CHM 341; IEE 280.

M BME 419 Biocontrol Systems. (3)
fall
Applies linear and nonlinear control systems techniques to analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body. Prerequisite with a grade of "C" (2.00) or higher: BME 350 (or its equivalent).

M BME 423 Biomedical Instrumentation Laboratory. (1)
fall
Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Fee. Prerequisite: EEE 334. Prerequisite with a grade of "C" (2.00) or higher: BME 235. Corequisite: BME 413.
General Studies: L (if credit also earned in BME 413)

M BME 434 Applications of Bioengineering Transport Phenomena. (3)
spring
Develops mathematical models of transport phenomena in physiological systems, medical devices, and pharmacokinetic analysis. Prerequisite: IEE 280. Prerequisite with a grade of "C" (2.00) or higher: BME 331.

M BME 451 Cell Biotechnology Laboratory. (3)
fall
Mammalian cell culture techniques, including mouse embryonic stem cells, the use of bioreactors, cell fractionation, and digital video imaging. Lecture, lab. Cross-listed as BIO 451. Credit is allowed for only BME 451 or BIO 451. Prerequisites: BIO 353; instructor approval.

M BME 490 Biomedical Engineering Capstone Design II. (4)
spring
Individual projects in medical systems or medical device design and development. Fee. Prerequisite with a grade of "C" (2.00) or higher: BME 417.

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

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

M 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)

M BME 496 Professional Seminar. (1–3)
fall and spring
Professional and ethical aspects with a discussion of responsibilities. Lecture, field trips. Prerequisite: instructor approval.

M 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/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.

Department of Chemical and Materials Engineering

fulton.asu.edu/~cme
480/965-3313
ECG 202

Subhash Mahajan, Chair

Regents' Professor: Mayer

Professors: Adams, Alford, Dey, Jabbour, Krause, Lin, Mahajan, Newman, Raupp, Sieradzki, Van Schilfgaarde, Wang, Zenhausern

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

Assistant Professors: Allen, Friesen, Heys, Park

Research Professor: Picraux

Associate Research Professors: Kotani, Mitkova, Singh

Assistant Research Professors: Chowdhury, Dillner

The faculty in the Department of Chemical and Materials Engineering offer the BSE degree in Chemical Engineering and in Materials Science and Engineering. Each of these majors builds on a broad base of knowledge within the basic and mathematical sciences and the engineering core. Each offers excellent career opportunities.

Chemical engineers design and operate processes that may include chemical change. They combine the science of chemistry with the discipline of engineering in order to solve complex problems in a wide variety of industries. Challenging job opportunities exist not only in the chemical and petroleum industries, but also in the plastics, electronics, computer, metals, space, food, drug, and health care industries. In these industries, chemical engineers practice in a wide variety of occupations, including environmental control, surface treatments, energy and materials transformation, biomedical applications, fermentation, protein recovery, extractive metallurgy, and separations. In the

environmental area, chemical engineers develop methods to reduce the pollution created in manufacturing processes, devise techniques to recover usable materials from wastes, design waste storage and treatment facilities, and design pollution control strategies.

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

CHEMICAL ENGINEERING—BSE

Chemical engineers are generally concerned with transfer within and between liquid, gas, and solid phases and 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.

ADMISSION REQUIREMENTS

The Preprofessional Program. Each student admitted to the Chemical Engineering program is designated a preprofessional student. Students follow the first-year sequence of courses listed in the curriculum outline. Included in the first two semester schedules are all skill-set courses or equivalents:

CHE	194	ST: Introduction to Chemical Engineering *CS*	3
CHM	113	General Chemistry I *SQ*	4
CHM	116	General Chemistry II *SQ*	4
ENG	101	First-Year Composition	3
ENG	102	First-Year Composition	3
MAT	294	ST: Calculus for Engineers I	3
MAT	294	ST: Calculus for Engineers II	3
PHY	121	University Physics I: Mechanics *SQ**	3
PHY	122	University Physics Laboratory I *SQ**	1
Total			27

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

The Professional Program. Admission to the professional program is competitive and granted to those applicants demonstrating the promise for professional success in Chemical Engineering. The admissions committee considers overall transfer and ASU GPA numbers as well as the transfer and ASU GPA numbers in Chemical Engineering skill-set courses. All students seeking professional status must be in the process of completing all of the skill-set courses and then follow the application procedure as described on the

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 93.

Chemical 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 encouraged to visit the Chemical Engineering undergraduate advising office before beginning the application process. All applications materials can be found on the Web at fulton.asu.edu/~cme.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Chemical Engineering. A minimum of 45 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 89.

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)
- ENG 108 English for Foreign Students (3)

Total 6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

HU/SB and awareness area courses[1] 15

Total 15

Literacy and Critical Inquiry

Six hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

CHM 113 General Chemistry I *SQ* 4
CHM 116 General Chemistry II *SQ* 4
CHM 233 General Organic Chemistry I 3
CHM 234 General Organic Chemistry II 3
CHM 237 General Organic Chemistry Laboratory I 1
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3] 3
Bioscience electives[4] 3

Total 25

Mathematical Studies

MAT 242 Elementary Linear Algebra 2
MAT 275 Modern Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers I 3
MAT 294 ST: Calculus for Engineers II 3
MAT 294 ST: Calculus for Engineers III 3

Total 14

General Studies/program requirements total 54

Major

CHE 194 ST: Introduction to Chemical Engineering *CS* 3
CHE 211 Introduction to Chemical Processing 3
CHE 231 Introduction to Transport Phenomena I: Fluids 3
CHE 334 Introduction to Transport Phenomena II: Heat and Mass Transfer 3
CHE 342 Introduction to Applied Chemical Thermodynamics 3
CHE 352 Transport Laboratories 3
CHE 432 Principles of Chemical Engineering Design 3
CHE 433 Modern Separations 3
CHE 442 Introduction to Chemical Reactor Design 3
CHE 451 Chemical Engineering Laboratory 3
CHE 461 Process Dynamic Control *CS* 3
CHE 462 Process Design *L* 3
IEE 220 Business and Industrial Engineering 3
MAE 384 Numerical Methods for Engineers 3
Engineering elective (200 level) 3
Technical electives[5] 15

Major courses total 60

Program total 120

---

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.

4 See "Bioscience Electives," on this page for a list of electives.

5 Students must complete a total of 15 semester hours of upper-division technical electives in the natural sciences, math, or engineering. These must include at least six hours of CHE courses and at least six hours of advanced chemistry content. Courses with advanced chemistry content include CHM, BCH, and approved CHE courses.

Bioscience Electives

BCH 361 Principles of Biochemistry (3)
BCH 461 General Biochemistry (3)
BCH 463 Biophysical Chemistry (3)
BIO 188 General Biology II (4)
BME 235 Physiology for Engineers (4)
BME 318 Biomaterials (4)
BME 411 Biomedical Engineering I (3)
MBB 245 Cellular and Molecular Biology *SQ* (4)
MBB 247 Applied Biosciences: Biotechnology (4)
MIC 205 Microbiology *SG* (3)
MIC 220 Biology of Microorganisms (3)
CHE 475 Biochemical Engineering (3)

Students should consult with their department academic advisors to ensure that all requirements are met.

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

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

another chemistry course may be required to enroll in CHM 113 and 116.

Chemical Engineering Areas of Study

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

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

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

Technical Electives
CHE 475 Biochemical Engineering....3
CHE 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....4

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

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....4
CHE 458 Semiconductor Material Processing....3
EEE 352 Properties of Electronic Materials....4
MSE 353 Introduction to Materials Processing and Synthesis....3
MSE 354 Experiments in Materials Synthesis and Processing....2
MSE 431 Corrosion and Corrosion Control....3
MSE 470 Polymers and Composites....3

Premedical. Students planning to attend medical school should select courses from those listed under the biomedical area. In addition, BIO 187, 188, and CHM 238 must be taken to satisfy medical-school requirements but are not counted toward the Chemical Engineering bachelor's degree.

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

CHE 494 ST: Advanced Process Control....3
MAE 436 Combustion....3

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

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

Technical Electives
CHE 458 Semiconductor Material Processing....3
CHE 494 Special Topics....1 to 4
EEE 352 Properties of Electronic Materials....4
EEE 435 Microelectronics....3
EEE 436 Fundamentals of Solid-State Devices....3
EEE 439 Semiconductor Facilities and Cleanroom Practices....3
MSE 353 Introduction to Materials Processing and Synthesis....3
MSE 354 Experiments in Materials Synthesis and Processing....2

Chemical Engineering
Program of Study
Typical Four-Year Sequence

First Year

First Semester
CHE 194 ST: Introduction to Chemical Engineering....3
CHM 113 General Chemistry I *SQ*....4
ENG 101 First-Year Composition....3
MAT 294 ST: Calculus for Engineers I....3
HU/SB and awareness area course....3
Total....16

Second Semester
CHM 116 General Chemistry II *SQ*....4
ENG 102 First-Year Composition....3

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.

MAT	294	ST: Calculus for Engineers II	3
PHY	121	University Physics I: Mechanics *SQ*[1]	3
PHY	122	University Physics Laboratory I *SQ*[1]	1
Total			14

Second Year

First Semester

CHE	211	Introduction to Chemical Processing	3
MAT	242	Elementary Linear Algebra	2
MAT	275	Modern Differential Equations *MA*	3
PHY	131	University Physics II: Electricity and Magnetism *SQ*[2]	3
Engineering elective (200 level)			3
Total			14

Second Semester

CHE	231	Introduction to Transport Phenomena I: Fluids	3
MAE	384	Numerical Methods for Engineers	3
MAT	294	ST: Calculus for Engineers III	3
HU/SB and awareness area courses			6
Total			15

Third Year

First Semester

CHE	334	Introduction to Transport Phenomena II: Heat and Mass Transfer	3
CHE	342	Introduction to Applied Chemical Thermodynamics	3
CHM	233	General Organic Chemistry I	3
CHM	237	General Organic Chemistry Laboratory I	1
Bioscience elective[3]			3
Technical Elective			3
Total			16

Second Semester

CHE	352	Transport Laboratories	3
CHE	433	Modern Separations	3
CHE	442	Introduction to Chemical Reactor Design	3
CHM	234	General Organic Chemistry II	3
IEE	220	Business and Industrial Engineering	3
Total			15

Fourth Year

First Semester

CHE	432	Principles of Chemical Engineering Design	3
CHE	451	Chemical Engineering Laboratory	3
CHE	461	Process Dynamic Control *CS*	3
HU/SB and awareness area course			3
Technical elective			3
Total			15

Second Semester

CHE	462	Process Design *L*	3
HU/SB and awareness area course			3
Technical electives			9
Total			15

Total degree requirements 120

[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] See "Bioscience Electives," page 394 for a list of electives.

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 production, and health professions. The space shuttle, lightweight cars, and today's fastest computers have all been developed using the latest materials technologies. In advancing today's technologies, materials engineers fulfill a wide range of job responsibilities that significantly impact other engineering disciplines and include

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

The Materials Science and Engineering degree program at ASU has outstanding faculty who have national reputations in the areas of both structural and electronic materials. The faculty bring significant professional expertise to classroom teaching, which is complemented by enlightening experimental work in the program's contemporary, well-equipped laboratory facilities. This atmosphere promotes quality undergraduate research projects and senior design projects that frequently result in patents and technical publications. Examples of recent patent applications include an improved method for producing artificial Teflon arteries and an improved technique for testing steel in air bag containers. Such preparation and experiences give the program's graduates an edge in seeking employment at the best companies or admission to the nation's leading graduate schools. The program's educational experience is also enhanced by numerous scholarships available to students ranging from entering freshmen to final-year seniors.

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

The mission of the Materials Science and Engineering degree program is to provide a solid educational foundation in the application of the principles of science and engineering toward the design, utilization, and improvement of materials in engineering components and systems for the betterment of society. This mission, with the associated objectives and outcomes, also supports the mission and goals of ASU and the Ira A. Fulton School of Engineering. To accomplish this mission, the program's graduates fulfill the following objectives: (1) graduates will have the strong educational foundation in materials science and engineering that promotes success in the broad range of career

opportunities available in graduate school, industry, and government; and (2) graduates will have the personal skills and values that promote their success in the rapidly changing, culturally diverse workplace that reflects the needs of contemporary society.

ADMISSION REQUIREMENTS

The Preprofessional Program. Each student admitted to the Materials Science and Engineering Program is designated a preprofessional student. Students follow the first- and second-year sequence of courses listed in the curriculum outline. Included in the first three semester schedules are all skill-set courses or equivalents:

CHM	114	General Chemistry for Engineers *SQ*	4
MAT	294	ST: Calculus for Engineers I	3
MAT	294	ST: Calculus for Engineers II	3
MAT	294	ST: Calculus for Engineers III	3
MSE	100	Introduction to Materials Engineering *CS*	3
PHY	121	University Physics I: Mechanics *SQ*[1]	3
PHY	122	University Physics Laboratory I *SQ*[1]	1
PHY	131	University Physics II: Electricity and Magnetism *SQ*[2]	3
PHY	132	University Physics Laboratory II *SQ*[2]	1
Total			24

[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 promise for professional success in Materials Science and Engineering. The admissions committee considers overall transfer and ASU GPA numbers as well as the transfer and ASU GPA numbers in Materials Science and Engineering skill-set courses. All students seeking professional status must be in the process of completing all of the skill-set courses and then follow the application procedure as described on the Materials 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 encouraged to visit the Materials Science and Engineering undergraduate advising office before beginning the application process.
All applications materials can be found on the Web at fulton.asu.edu/~cme.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Materials Science and Engineering. A minimum of 45 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 89.

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

HU/SB and awareness area courses			15
HU/SB subtotal			15

Literacy and Critical Inquiry

Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

CHM	114	General Chemistry for Engineers *SQ*	4
PHY	121	University Physics I: Mechanics *SQ*[1]	3
PHY	122	University Physics Laboratory I *SQ*[1]	1
PHY	131	University Physics II: Electricity and Magnetism *SQ*[2]	3
PHY	132	University Physics Laboratory II *SQ*[2]	1
Math or science elective			3
Natural science/basic sciences subtotal			15

Mathematical Studies

MAT	275	Modern Differential Equations *MA*	3
MAT	294	ST: Calculus for Engineers I	3
MAT	294	ST: Calculus for Engineers II	3
MAT	294	ST: Calculus for Engineers III	3
MAT	343	Applied Linear Algebra	3
Mathematical studies subtotal			15
General Studies/school requirements total			45

Major

BME	111	Engineering Perspectives on Biological Systems	3
IEE	220	Business and Industrial Engineering	3
MSE	100	Introduction to Materials Engineering *CS*	3
MSE	211	Introduction to Mechanics of Materials	3
MSE	215	Materials Synthesis	3
MSE	250	Structure and Properties of Materials	3
MSE	315	Mathematical and Computational Methods in Materials	3
MSE	330	Thermodynamics of Materials	3
MSE	335	Materials Kinetics and Processing	3
MSE	355	Materials Structure and Microstructure	3

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.

MSE 356 Materials Structure and Microstructure Lab 1
MSE 358 Introduction to Electronic, Magnetic, and Optical Properties 3
MSE 420 Physical Metallurgy 3
MSE 421 Physical Metallurgy Laboratory 1
MSE 440 Mechanical Properties of Solids 3
MSE 450 Introduction to Materials Characterization 3
MSE 451 Introduction to Materials Characterization Lab 1
MSE 470 Polymers and Composites 3
MSE 471 Introduction to Ceramics 3
MSE 482 Materials Engineering Design *L* 3
MSE 490 Capstone Design Project 3
Select two 300- or 400-level science courses from biology, chemistry, geology, or physics 6
Technical electives 6
Total 69

Program total 120

[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 Areas of Study

Technical electives may be selected from one or more of the following areas. A student may select a general area or a set of courses from engineering, mathematics, or science 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 4
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 233 General Organic Chemistry I 3
CHM 234 General Organic Chemistry II 3
CHM 471 Solid-State Chemistry 3
EEE 435 Microelectronics 3
EEE 436 Fundamentals of Solid-State Devices 3
EEE 439 Semiconductor Facilities and Cleanroom Practices 3

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

MAE 342 Principles of Design 3
MAE 442 Mechanical Systems Design 4
MSE 431 Corrosion and Corrosion Control 3
MSE 441 Analysis of Material Failures 3

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

CHE 458 Semiconductor Material Processing 3
EEE 435 Microelectronics 3
EEE 436 Fundamentals of Solid-State Devices 3
EEE 439 Semiconductor Facilities and Cleanroom Practices 3

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

CHE 458 Semiconductor Material Processing 3
IEE 300 Economic Analysis for Engineers 3
IEE 360 Manufacturing Processes 3
or MAE 351 Manufacturing Processes (3)
IEE 361 Manufacturing Processes Lab 1
IEE 368 Facilities Analysis and Design *L* 3
IEE 369 Work Analysis and Design *L* 3
IEE 431 Engineering Administration 3
IEE 437 Human Factors Engineering 3
IEE 461 Production Control 3
IEE 463 Computer-Aided Manufacturing and Control *CS* 3
MAE 322 Mechanics of Materials 4
MAE 342 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 322 Mechanics of Materials 4
MAE 342 Principles of Design 3
MAE 415 Vibration Analysis 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 233 General Organic Chemistry I 3
CHM 234 General Organic Chemistry II 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 114 General Chemistry for Engineers *SQ* 4

ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
MSE 100 Introduction to Materials Engineering *CS* 3
HU/SB and awareness area course[1] 3
Total 16

Second Semester
ENG 102 First-Year Composition 3
MAT 294 ST: Calculus for Engineers II 3
MSE 250 Structure and Properties of Materials 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1
HU/SB and awareness area course[1] 3
Total 16

Second Year

First Semester
BME 111 Engineering Perspectives on Biological Systems 3
MAT 294 ST: Calculus for Engineers III 3
MSE 215 Materials Synthesis 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3] 3
PHY 132 University Physics Laboratory II *SQ*[3] 1
Total 13

Second Semester
MAT 275 Modern Differential Equations *MA* 3
MAT 343 Applied Linear Algebra 3
MSE 211 Introduction to Mechanics of Materials 3
HU/SB awareness area course[1] 3
Science or mathematics elective 3
Total 15

Third Year

First Semester
IEE 220 Business and Industrial Engineering 3
MSE 315 Mathematical and Computer Methods in Materials 3
MSE 330 Thermodynamics of Materials 3
MSE 355 Materials Structure and Microstructure 3
MSE 356 Materials Structure and Microstructure Lab 1
HU/SB awareness area course[1] 3
Total 16

Second Semester
MSE 335 Materials Kinetics and Processing 3
MSE 358 Introduction to Electronic, Magnetic, and Optical Properties 3
MSE 420 Physical Metallurgy 3
MSE 421 Physical Metallurgy Laboratory 1
MSE 450 Introduction to Materials Characterization 3
MSE 451 Introduction to Materials Characterization Lab 1
Total 14

Fourth Year

First Semester
MSE 440 Mechanical Properties of Solids 3
MSE 470 Polymers and Composites 3
MSE 471 Introduction to Ceramics 3
MSE 482 Materials Engineering Design *L* 3
Advanced science elective 3
Total 15

Second Semester
MSE 490 Capstone Design Project 3
Advanced science elective 3
HU/SB awareness area course[1] 3
Technical elective 6
Total 15

Total degree requirements 120

[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.

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)

M CHE 100 Introduction to Chemical Engineering. (3)
fall
Introduces design in chemical engineering, teaming, chemical engineering profession, computer models, communication skills, quality and customer satisfaction. Fee. Prerequisites: high school algebra and computing and physics courses (or their equivalents). *General Studies: CS*

M CHE 211 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 (or 294 ST: Calculus for Engineers II).

M CHE 231 Introduction to Transport Phenomena I: Fluids. (3)
spring
Transport phenomena, with emphasis on fluid systems. Credit is allowed for only CHE 231 or 501. Prerequisites: CHE 211; MAT 271 (or 294 ST: Calculus for Engineers II).

M CHE 334 Introduction to Transport Phenomena II: Heat and Mass Transfer. (3)
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 231.

M CHE 342 Introduction to Applied Chemical Thermodynamics. (3)
fall
Applies conservation and accounting principles with nonideal property estimation techniques. Credit is allowed for only CHE 342 or 504. Prerequisite: CHE 211. Pre- or corequisite: MAT 272 or 294 ST: Calculus for Engineers III.

M CHE 352 Transport Laboratories. (3)
spring
Introduces engineering lab equipment, data collection, and analysis; strengthens ability to generate written reports and oral presentations; reinforces teamwork skills; strengthens and extends the understanding of earlier technical contents in the curriculum. Integrated lecture/lab. Fee. Prerequisite: CHE 334.

M CHE 432 Principles of Chemical Engineering Design. (3)
fall
Multicomponent distillation, engineering economics, equipment sizing and costs, plant operation economics, and simulation and optimization techniques. Prerequisites: CHE 334, 342.

M CHE 433 Modern Separations. (3)
spring
Design of modern separation equipment in chemical engineering other than fractionation. Prerequisites: CHE 334, 342.

M 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.

M CHE 451 Chemical Engineering Laboratory. (3)
fall
Operation, control, and design of experimental and industrial process equipment; independent research projects. Integrated lecture/lab. Fee. Prerequisites: CHE 334, 352; MAE 384.

M CHE 458 Semiconductor Material Processing. (3)
selected semesters
Introduces the processing and characterization of electronic materials for semiconductor applications. Prerequisites: CHE 334, 342.

M CHE 461 Process Dynamic Control. (3)
fall
Process dynamics, instrumentation, and feedback applied to automatic process control. Integrated lecture/lab. Fee. Prerequisites: MAE 384; MAT 274.
General Studies: CS

M 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

M CHE 469 Air Quality Engineering. (3)
selected semesters
Chemical and physical processes by which air pollutants are generated and controlled with an emphasis on urban air quality. Cross-listed as CEE 469. Credit is allowed for only CHE 469 or CEE 469. Prerequisite: CEE 361 or CHE 334.

M 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.

M CHE 475 Biochemical Engineering. (3)
selected semesters
Applies chemical engineering methods, mass transfer, thermodynamics, and transport phenomena to industrial biotechnology. Prerequisite: instructor approval.

M 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.

M 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.

M CHE 478 Industrial Water Quality Engineering. (3)
fall
Chemical treatment processing, quality criteria and control, system design, and water pollutants. Prerequisites: CHE 231; senior standing.

M CHE 490 Chemical Engineering Projects. (1–5)
fall, spring, summer
Individual projects in chemical engineering operations and design. Prerequisite: instructor approval.

M CHE 492 Honors Directed Study. (1–6)
selected semesters

M CHE 493 Honors Thesis. (1–6)
selected semesters

M CHE 494 Special Topics. (1–4)
fall and spring
Topics may include the following:
- Advanced Process Control. (3)
- Biotechnology Techniques. (3)

M CHE 496 Professional Seminar. (1–3)
fall and spring
Professional and ethical aspects with a discussion of responsibilities. Lecture, field trips. Prerequisite: instructor approval.

M 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)

M MSE 100 Introduction to Materials Engineering. (3)
fall
Engineering design process, concepts about materials, and the materials engineering profession, including teaming, computer models, communication, and societal impact. Fee. Prerequisites: high school algebra and computing and physics courses (or their equivalents).
General Studies: CS

M MSE 111 Challenges in Materials Engineering. (1)
fall
Introduces current issues and concepts of materials engineering, relationship between materials properties, application to engineering problems.

M MSE 208 Patterns in Nature. (4)
fall and spring
Project-oriented science course with computer training to develop critical thinking and technical skills for student-oriented K–12 science lessons. Lecture, lab. Cross-listed as PHS 208. Credit is allowed for only MSE 208 or PHS 208. Fee. Prerequisite: college-level science course or instructor approval.
General Studies: SQ

M MSE 211 Introduction to Mechanics of Materials. (3)
spring
Topics include stress, strain, elasticity, axial loading, torsion, bending, yield criteria, fracture, general energy methods and Castigliano’s Theorem. Prerequisites: PHY 121, 122. Pre- or corequisite: MAT 272 (or 294 ST: Calculus for Engineers III).

M MSE 215 Materials Synthesis. (3)
fall
Introduces contemporary techniques for synthesizing both traditional and novel materials and the corresponding correlation to synthesized materials properties. Lecture, lab. Prerequisites: CHM 114 (or 116); MSE 250.

M MSE 250 Structure and Properties of Materials. (3)
fall, spring, summer session 1
Basic concepts of material structure and its relation to properties. Application to engineering problems. Prerequisites: CHM 114 or 116.

M MSE 308 Sensing the World. (4)
fall and spring
Project-oriented science course develops critical thinking and technical skill using Internet modules on the five senses. Integrated lecture/lab. Prerequisite: college-level science course or instructor approval.

M MSE 315 Mathematical and Computer Methods in Materials. (3)
fall
Mathematical, computational, and statistical methods and computer programming used to model materials science phenomena and materials engineering applications. Prerequisites: preferably MAT 275 (or 274); MSE 250.

M MSE 330 Thermodynamics of Materials. (3)
fall
Principles of statistical mechanics, statistical thermodynamics of single crystals, solutions, phase equilibrium, free energy of reactions, free electron theory, and thermodynamics of defects. Prerequisite: MSE 250.

M MSE 335 Materials Kinetics and Processing. (3)
spring
Introduces kinetics in processing of materials as illustrated through real-world materials processing examples. Integrated lecture/lab. Prerequisites: MSE 250, 330.

M 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 MSE 250 and PHY 131 (or their equivalents).

M 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).

M MSE 355 Materials Structure and Microstructure. (3)
fall
Elements of the structure of metals and alloys, measurement of mechanical properties, and optical metallography. Fee. Prerequisite: MSE 250.

M MSE 356 Materials Structure and Microstructure Lab. (1)
fall
Lab experiments correlating atomic structure, defects and microstructure of processed metals, ceramics polymers and composites to their mechanical and thermal properties. Lab. Fee. Prerequisite: MSE 250. Corequisite: MSE 355.

M MSE 358 Introduction to Electronic, Magnetic, and Optical Properties. (3)
spring
Introduces electrical, optical, and magnetic properties of solids and microstructure effects as examined through materials-based examples. Prerequisites: CHM 114 (or 116); MSE 250; PHY 131.

M MSE 394 Special Topics. (1–4)
selected semesters
Topics may include the following:
- Computer and Experimental Methods in Materials. (3)
- Computer Modeling
  Fee.

M MSE 420 Physical Metallurgy. (3)
spring
Crystal structure and defects. Phase diagrams, metallography, solidification and casting, deformation, and annealing. Prerequisite: MSE 250.

M 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.

M MSE 431 Corrosion and Corrosion Control. (3)
spring in odd years
Introduces corrosion mechanisms and methods of preventing corrosion. Topics include: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: MSE 250.

M MSE 440 Mechanical Properties of Solids. (3)
fall
Effects of environmental and microstructural variables of mechanical properties, including plastic deformation, fatigue, creep, brittle fracture, and internal friction. Credit is allowed for only MSE 440 or 516. Prerequisite: MSE 250.

M MSE 441 Analysis of Material Failures. (3)
spring in even years
Identifies types of failures. Analytical techniques. Fractography, SEM, nondestructive inspection, and metallography. Mechanical and electronic components. Credit is allowed for only MSE 441 or 512. Prerequisite: MSE 250.

M MSE 450 Introduction to Materials Characterization. (3)
spring
Introduces materials characterization techniques for analysis of thin films and bulk materials by TEM, SEM, XRD, XPS, and AES. Fee. Prerequisite: MSE 250.

M MSE 451 Introduction to Materials Characterization Lab. (1)
spring
Lab for materials characterization techniques for analysis of thin films and bulk materials by TEM, SEM, XRD, XPS, and AES. Lab. Fee. Corequisite: MSE 450.

M MSE 470 Polymers and Composites. (3)
fall
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MAE 455. Credit is allowed for only MAE 455 or MSE 470. Prerequisites: MSE 211 (or CEE 213 or MAE 213), 250.

M MSE 471 Introduction to Ceramics. (3)
fall
Principles of structure and property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: MSE 250.

M MSE 482 Materials Engineering Design. (3)
fall
Principles of the design process. Feasibility and optimization. Manufacturing processes, materials selection, failure analysis, and economics. Prerequisites: ENG 101 (or 105 or 107); MSE 354, 355.
General Studies: L

M MSE 490 Capstone Design Project. (1–3)
spring
For small groups in fundamental or applied aspects of engineering materials; emphasizes experimental problems and design. Fee. Prerequisites: MSE 330, 440, 450.

M MSE 492 Honors Directed Study. (1–6)
selected semesters

M MSE 493 Honors Thesis. (1–6)
selected semesters

M MSE 494 Special Topics. (1–4)
selected semesters
Topics may include the following:
- Composite Materials. (3)
- Electronic, Optical, and Magnetic Properties of Materials. (3)
- Engineering Disasters: Heavy Metal Toxicity
- Growth and Processing of Semiconductors. (3)
- Nanomaterials: Synthesis and Evaluation. (3)
- Scanning Probe Microscopy. (3)
- Vacuum Systems Science and Engineering. (3)

M MSE 499 Individualized Instruction. (1–3)
selected semesters

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

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/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.

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 93.

Department of Civil and Environmental Engineering

fulton.asu.edu/civil
480/965-3589
ECG 252

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; water reuse; and sustainability.

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.

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 120 semester hours of course work. A minimum of 45 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/program requirements.....47
Civil Engineering major.....67
Minimum requirement.....120

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)

First-year composition total.....6

General Studies/Program Requirements

Humanities and Fine Arts/Social and Behavioral Sciences/ Awareness

CEE 400 Earth Systems Engineering and Management.....3
ECN 211 Macroeconomic Principles *SB*.....3
or ECN 212 Microeconomic Principles *SB (3)*
HU courses.....3–6
SB courses.....3–6
Minimum total.....15

Awareness Areas (C, G, H)

Students must select at least two courses to satisfy the three awareness areas.

Literacy and Critical Inquiry

Six semester hours of literary and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

CHM 114 General Chemistry for Engineers *SQ*[1].....4
or CHM 116 General Chemistry II *SQ*[1, 2](4)
PHY 121 University Physics I: Mechanics *SQ*[3].....3
PHY 122 University Physics Laboratory I *SQ*[3].....1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[1, 4].....3
PHY 132 University Physics Laboratory II *SQ*[1, 4].....1
Basic science elective.....3
Total.....15

Mathematical Studies

IEE 280 Probability and Statistics for Engineering Problem Solving *CS*.....3
MAT 242 Elementary Linear Algebra[1].....2
MAT 275 Modern Differential Equations *MA*[1].....3
MAT 294 ST: Calculus for Engineers I.....3
MAT 294 ST: Calculus for Engineers II[1].....3
MAT 294 ST: Calculus for Engineers III[1].....3
Total.....17

General Studies/program requirements total.....47

1 This is a skill-set course.
2 CHM 116 has a prerequisite of CHM 113. Degree credit for CHM 113 is awarded only with departmental approval.
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.

Civil Engineering Major

CEE 100 Introduction to Civil and Environmental Engineering *CS*[1].....3
CEE 211 Engineering Mechanics: Statics and Dynamics[1].....4
CEE 213 Introduction to Deformable Solids.....3
CEE 300 Engineering Business Practice.....3
CEE 321 Structural Analysis and Design.....4
CEE 341 Fluid Mechanics for Civil Engineers.....4
CEE 351 Geotechnical Engineering.....4
CEE 353 Civil Engineering Materials.....3
CEE 361 Introduction to Environmental Engineering.....4
CEE 372 Transportation Engineering.....4
CEE 384 Numerical Methods for Engineers.....3
CEE 486 Integrated Civil Engineering Design *L*.....3
MAE 240 Thermofluids I.....4
or EEE 202 Circuits I (4)
Design courses[2].....6
Technical courses[3].....15
Total.....67

Degree requirements total.....120

1 This is a skill-set course.
2 For information on design course options, see "Design Courses for the Degree Without a Concentration," page 404.

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 93.

[3] For information on technical course options, see "Technical Courses for the Degree Without a Concentration," page 404.

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
CEE 452 Foundations 3
CEE 462 Unit Operations in Environmental Engineering 3
or CEE 466 Urban Water System Design (3)

Technical Courses for the Degree Without a Concentration

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

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

Environmental Engineering
CEE 462 Unit Operations in Environmental Engineering 3
CEE 466 Urban Water System Design 3
CEE 467 Environmental Microbiology 3
CEE 469 Air Quality Engineering 3

Geotechnical/Geoenvironmental Engineering
CEE 452 Foundations 3

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

Transportation/Materials Engineering
CEE 281 Surveying 3
CEE 412 Pavement Analysis and Design 3
CEE 474 Transportation Systems Engineering 3
CEE 475 Highway Geometric Design 3
CEE 481 Civil Engineering Project Management 3
CEE 483 Highway Materials, Construction, and Quality 3

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

Design Courses for the Degree with the Construction Engineering Concentration

CEE 420 Steel Structures 3
CEE 452 Foundations 3
Total 6

Technical Courses for the Degree with the Construction Engineering Concentration

CEE 281 Surveying 3
CEE 412 Pavement Analysis and Design 3
or CEE 483 Highway Materials, Construction, and Quality (3)
CEE 421 Concrete Structures 3
CEE 481 Civil Engineering Project Management 3
CON 496 Construction Contract Administration *L* 3
Total 15

Design Courses for the Degree with the Environmental Engineering Concentration

CEE 441 Water Resources Engineering 3
CEE 466 Urban Water System Design 3
Total 6

Technical Courses for the Degree with the Environmental Engineering Concentration

BIO 320 Fundamentals of Ecology 3
or BCH 361 Principles of Biochemistry (3)
or CHM 302 Environmental Chemistry (3)
or CHM 341 Elementary Physical Chemistry (3)
or PUP 442 Environmental Planning (3)
or PUP 475 Environmental Impact Assessment (3)
CEE 440 Engineering Hydrology 3
CEE 462 Unit Operations in Environmental Engineering 3
CEE 467 Environmental Microbiology 3
CEE 469 Air Quality Engineering 3
or Technical elective* (3)

Total 15

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

Civil Engineering Program of Study
Typical Four-Year Sequence

First Year

First Semester
CEE 100 Introduction to Civil and Environmental Engineering *CS* 3
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[1] (4)
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
Total 13

Second Semester
ECN 111 Macroeconomic Principles *SB* 3
or ECN 112 Microeconomic Principles *SB* (3)
ENG 102 First-Year Composition 3
MAT 242 Elementary Linear Algebra 2
MAT 294 ST: Calculus for Engineers II 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1
Total 15

Second Year

First Semester
CEE 211 Engineering Mechanics: Statics and Dynamics 4
MAT 275 Modern Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers III 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3] 3
PHY 132 University Physics Laboratory II *SQ*[3] 1
Total 14

Second Semester

CEE	213	Introduction to Deformable Solids	3
EEE	202	Circuits I	4
		or MAE 240 Thermofluids I (4)	
IEE	280	Probability and Statistics for Engineering Problem Solving *CS*	3
HU/SB and awareness area course[4]			3
Basic science elective			3
Total			16

Third Year

First Semester

CEE	300	Engineering Business Practice	3
CEE	321	Structural Analysis and Design	4
CEE	353	Civil Engineering Materials	3
CEE	372	Transportation Engineering	4
CEE	384	Numerical Methods for Engineers *CS*	3
Total			17

Second Semester

CEE	341	Fluid Mechanics for Civil Engineers	4
CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	400	Earth Systems Engineering and Management	3
Total			15

Fourth Year

First Semester

Design elective			3
HU/SB and awareness area course[4]			3
Technical electives			9
Total			15

Second Semester

CEE	486	Integrated Civil Engineering Design *L*	3
Design elective			3
HU/SB and awareness area course[4]			3
Technical electives			6
Total			15

Minimum total 120

---

1 CHM 116 has a prerequisite of CHM 113. Degree credit for CHM 113 is awarded only with departmental approval.

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

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

4 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Students should consider the following list of electives to enhance communication and management skills: COM 100, 110, 320; CON 101; GCU 141, 361, 421, 442; PUP 100, 200.

Construction Engineering Concentration
Program of Study
Typical Four-Year Sequence

First Year

First Semester

CEE	100	Introduction to Civil and Environmental Engineering *CS*	3
CHM	114	General Chemistry for Engineers *SQ*	4
		or CHM 116 General Chemistry II *SQ*[1] (4)	
ENG	101	First-Year Composition	3
MAT	294	ST: Calculus for Engineers I	3
Total			13

Second Semester

ECN	211	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
ENG	102	First-Year Composition	3
MAT	242	Elementary Linear Algebra	2
MAT	294	ST: Calculus for Engineers II	3
PHY	121	University Physics I: Mechanics *SQ*[2]	3
PHY	122	University Physics Laboratory I *SQ*[2]	1
Total			15

Second Year

First Semester

CEE	211	Engineering Mechanics: Statics and Dynamics	4
MAT	275	Modern Differential Equations *MA*	3
MAT	294	ST: Calculus for Engineers III	3
PHY	131	University Physics II: Electricity and Magnetism *SQ*[3]	3
PHY	132	University Physics Laboratory II *SQ*[3]	1
Total			14

Second Semester

CEE	213	Introduction to Deformable Solids	3
EEE	202	Circuits I	4
IEE	280	Probability and Statistics for Engineering Problem Solving *CS*	3
HU/SB and awareness area course[4]			3
Basic science elective			3
Total			16

Third Year

First Semester

CEE	300	Engineering Business Practice	3
CEE	321	Structural Analysis and Design	4
CEE	353	Civil Engineering Materials	3
CEE	372	Transportation Engineering	4
CEE	384	Numerical Methods for Engineers	3
Total			17

Second Semester

CEE	341	Fluid Mechanics for Civil Engineers	4
CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	400	Earth Systems Engineering and Management	3
Total			15

Fourth Year

First Semester

CEE	281	Surveying	3
CEE	420	Steel Structures	3
CEE	452	Foundations	3
CEE	412	Pavement Analysis and Design	3
		or CEE 483 Highway Materials, Construction, and Quality (3)	
HU/SB and awareness area course[4]			3
Total			15

Second Semester

CEE	421	Concrete Structures	3
CEE	481	Civil Engineering Project Management	3
CEE	486	Integrated Civil Engineering Design *L*	3
CON	496	Construction Contract Administration *L*	3

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/ quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.

HU/SB and awareness area course[4] 3
Total 15

Minimum total 120

[1] CHM 116 has a prerequisite of CHM 113. Degree credit for CHM 113 is awarded only with departmental approval.
[2] Both PHY 121 and 122 must be taken to secure SQ credit.
[3] Both PHY 131 and 132 must be taken to secure SQ credit.
[4] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. Students should consider the following list of electives to enhance communication and management skills: COM 100, 110, 320; CON 101; PUP 100, 200.

Environmental Engineering Concentration
Program of Study
Typical Four-Year Sequence

First Year

First Semester
CEE 100 Introduction to Civil and Environmental Engineering *CS* 3
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[1] (4)
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
Total 13

Second Semester
ECN 211 Macroeconomic Principles *SB* 3
or ECN 212 Microeconomic Principles *SB* (3)
ENG 102 First-Year Composition 3
MAT 242 Elementary Linear Algebra 2
MAT 294 ST: Calculus for Engineers II 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1
Total 15

Second Year

First Semester
CEE 211 Engineering Mechanics: Statics and Dynamics 4
MAT 275 Modern Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers III 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3]3
PHY 132 University Physics Laboratory II *SQ*[3] 1
Total 14

Second Semester
CHM 231 Elementary Organic Chemistry *SQ*[4] 3
CEE 213 Introduction to Deformable Solids 3
MAE 240 Thermofluids I 4
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
HU/SB and awareness area course[5] 3
Total 16

Third Year

First Semester
CEE 300 Engineering Business Practice 3
CEE 341 Fluid Mechanics for Civil Engineers 4
CEE 353 Civil Engineering Materials 3
CEE 361 Introduction to Environmental Engineering 4
CEE 384 Numerical Methods for Engineers 3
Total 17

Second Semester
CEE 321 Structural Analysis and Design 4
CEE 351 Geotechnical Engineering 4
CEE 372 Transportation Engineering 4
CEE 400 Earth Systems Engineering and Management 3
Total 15

Fourth Year

First 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 440 Engineering Hydrology 3
or CEE 469 Air Quality Engineering (3)
CEE 466 Urban Water System Design 3
CEE 467 Environmental Microbiology 3
HU/SB and awareness area course[5] 3
Total 15

Second Semester
CEE 441 Water Resources Engineering 3
CEE 462 Unit Operations in Environmental Engineering 3
CEE 486 Integrated Civil Engineering Design *L* 3
HU/SB and awareness area course[5] 3
Technical elective[6] 3
Total 15

Minimum total 120

[1] CHM 116 has a prerequisite of CHM 113. Degree credit for CHM 113 is awarded only 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 CHM 231 and 235 must be taken to secure SQ credit. Students who pursue this major fulfill this GS requirement through other courses.
[5] 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: CON 101; GCU 141, 361, 442; PUP 100, 200.
[6] This course is selected from the list of technical courses for the degree without a concentration.

ADMISSION REQUIREMENTS

Preprofessional Program. With the exception of a few outstanding students, all students will initially be admitted to the preprofessional level. The student follows the first- and second-year sequence of courses listed in the curriculum outline for his or her particular program. Included in the first three semester schedules are the skill-set courses:

CEE 100 Introduction to Civil and Environmental Engineering *CS* 3
CEE 211 Engineering Mechanics: Statics and Dynamics 4
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[1] (4)
MAT 242 Elementary Linear Algebra 2
MAT 275 Modern Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers II 3
MAT 294 ST: Calculus for Engineers III 3

PHY	131	University Physics II: Electricity and Magnetism *SQ*[2]3
PHY	132	University Physics Laboratory II *SQ*[2] 1
Total		 26

[1] CHM 116 has a prerequisite of CHM 113. Degree credit for CHM 113 is awarded only with departmental approval.

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

Professional Program. Admission to the professional program is competitive and granted to those applicants demonstrating the highest promise for professional success in Civil and Environmental Engineering measured by their average GPA of the skill-set courses. For transfer students, both transfer and ASU GPA numbers in the skill-set courses are considered. All students seeking professional status must have completed or be in the process of completing all the skill-set courses and then follow the application procedure as described on the Civil and Environmental 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 Civil and Environmental Engineering undergraduate advising office before beginning the application process. All application materials can be found on the Web at www.fulton.asu.edu/civil.

GRADUATION REQUIREMENTS

Students must complete CEE courses in order (100-level followed by 200-level, etc.). CEE 486 is taken in the last semester of course work. This order of courses is important not only to satisfy the prerequisite requirements, but also to avoid time conflicts that may exist among different level courses. CEE 300- and 400-level courses must be completed with an average grade of 2.00 or higher. The total GPA of all ASU courses must be 2.00 or higher.

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 school.

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 89.

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—BSD[1] Lower-Division Requirements," page 320.

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 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)

M CEE 100 Introduction to Civil and Environmental Engineering. (3)
fall and spring or summer
Introduces basics of civil and environmental engineering design, team work, ethics, communication and management skills, modeling, problem solving, computer applications. Fee. Prerequisites: high school algebra and computing and physics (or their equivalents).
General Studies: CS

M CEE 211 Engineering Mechanics: Statics and Dynamics. (4)
fall, spring, summer
Force systems, equilibrium, structural analysis, area-related properties, kinematics and dynamics of particles and rigid bodies, energy and conservation principles. Lecture, recitation. Prerequisites: CEE 100; MAT 272 (or 294 ST: Calculus for Engineers III); PHY 121, 122.

M CEE 213 Introduction to Deformable Solids. (3)
fall, spring, summer
Strain-displacement and stress-strain-temperature relations. Stresses and deformations due to axial, shear, torsional and bending moments. Buckling, stability. Lecture, recitation. Prerequisites: CEE 211; MAT 275.

M CEE 281 Surveying. (3)
fall, spring, summer
Theory and field work in construction and land surveys. Cross-listed as CON 241. Credit is allowed for only CEE 281 or CON 241. Fee. Lecture, lab. Prerequisite: MAT 270 (or 294 ST: Calculus for Engineers I).

M CEE 300 Engineering Business Practice. (3)
fall, spring, summer
Engineering economic principles, cost/benefit analysis, project financing and delivery, management of engineering design, business practices, ethical and professional responsibilities. Prerequisite: CEE 213.
General Studies: L

M 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. Prerequisite: CEE 213. Pre- or corequisites: CEE 384; IEE 280.

M CEE 341 Fluid Mechanics for Civil Engineers. (4)
fall and spring
Fundamental principles and methods of fluid mechanics forming the analytical basis for water resources engineering. Conduit and open channel flow. Fee. Lecture, lab. Prerequisite: CEE 213. Pre- or corequisites: CEE 384; IEE 280.

M 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. Fee. Lecture, lab. Prerequisite: CEE 213. Pre- or corequisites: CEE 384; IEE 280.

M CEE 353 Civil Engineering Materials. (3)
fall and spring
Structure and behavior of civil engineering materials, including steel, aggregate, concrete, masonry, asphalt, wood, composites. Atomic structure and engineering applications. Fee. Lecture, lab. Prerequisite: CEE 213.

M 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

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 93.

treatment systems designs. Fee. Lecture, lab. Prerequisite: CEE 213. Pre- or corequisites: CEE 384; IEE 280.

M 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. Prerequisite: CEE 213. Pre- or corequisites: CEE 384; IEE 280.

M CEE 384 Numerical Methods for Engineers. (3)
fall and spring
Numerical methods and computational tools for selected problems in engineering. Cross listed as MAE 384. Credit is allowed for only CEE 384 or MAE 384. Prerequisites: preferably MAT 275 or 274, preferably 343 or 242 or 342. Pre- or corequisite: MAT 272 or 294 ST: Calculus for Engineers III.

M CEE 400 Earth Systems Engineering and Management. (3)
fall and spring
Introduces earth systems engineering and management, and the technological, economic and cultural systems underlying the terraformed Earth Prerequisite: CEE 300. Prerequisite for non-CEE major: instructor approval.
General Studies: H

M CEE 412 Pavement Analysis and Design. (3)
fall
Design of flexible and rigid pavements for highways and airports. Surface, base, and subgrade courses. Cost analysis and pavement selection. Credit is allowed for only CEE 412 or 511. Prerequisites: CEE 351, 353.

M CEE 420 Steel Structures. (3)
fall
Behavior of structural components and systems. Design of steel members and connections. Load and resistance factor design methods. Lecture, recitation. Prerequisite: CEE 321.

M 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.

M 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.

M 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.

M CEE 440 Engineering Hydrology. (3)
fall
Descriptive hydrology; hydrologic cycle, models, and systems. Rain-runoff models. Hydrologic design. Concepts, properties, and basic equations of groundwater flow. Prerequisite: CEE 341.

M 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.

M CEE 452 Foundations. (3)
fall
Applies soil mechanics to foundation systems, bearing capacity, lateral earth pressure, and slope stability. Prerequisite: CEE 351.

M CEE 462 Unit Operations in Environmental Engineering. (3)
spring
Design and operation of unit processes for water and wastewater treatment. Prerequisite: CEE 361.

M CEE 466 Urban Water System Design. (3)
fall
Capacity; planning and design of water supply; domestic and storm drainage; and solid waste systems. Prerequisites: CEE 341, 361.

M CEE 467 Environmental Microbiology. (3)
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. Fee. Lecture, lab. Prerequisite: CEE 361 or MIC 220.

M CEE 469 Air Quality Engineering. (3)
selected semesters
Chemical and physical processes by which air pollutants are generated and controlled with an emphasis on urban air quality. Cross-listed as CHE 469. Credit is allowed for only CEE 469 or CHE 469. Prerequisite: CEE 361 or CHE 334.

M CEE 474 Transportation Systems Engineering. (3)
selected semesters
Introduces transportation systems and modeling, traffic characteristic analysis, traffic predictions, highway capacity, signal timing, transportation systems management, and transit. Prerequisites: CEE 372, 384.

M CEE 475 Highway Geometric Design. (3)
spring
Design of visible elements of roadway, design controls, at-grade intersections, freeways, and interchanges. Lecture, computer lab. Fee. Credit is allowed for only CEE 475 or 576. Prerequisite: CEE 372.

M 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.

M CEE 483 Highway Materials, Construction, and Quality. (3)
once a year
Properties of highway materials, including aggregates, asphalt concrete, and portland cement concrete; construction practice; material delivery, placement, and compaction; quality control. Credit is allowed for only CEE 483 or 583. Lecture, field trips. Prerequisites: CEE 351, 353, 372.

M CEE 486 Integrated Civil Engineering Design. (3)
fall and spring
Requires completion of a civil engineering design in a simulated practicing engineering environment. Limited to undergraduates in their final semester. Lecture, team learning. Prerequisites: CEE 321, 341, 351, 361, 372.
General Studies: L

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

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

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

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

Graduate-Level Courses. For information about courses numbered from 500 to 799, see the *Graduate Catalog*, or access www.asu.edu/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.

Department of Computer Science and Engineering

fulton.asu.edu/cse
480/965-3190
BYENG 501

Sethuraman Panchanathan, Chair

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

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

Assistant Professors: Cam, Chatha, Chen, Davulcu, Huang, Janssen, Kim, Konjevod, J. Lee, Li, Ryu, Sarjoughian, Sundaram, Syrotiuk, Wonka, Ye

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.

Computing is integral to many other fields, including bioinformatics. The Department of Computer Science and Engineering is strategically positioned in the university to provide educational and research opportunities for students in computing in many related disciplines.

Computer science and computer engineering deal with the study, design, development, construction, and application of computing technology. 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.

An integrated bachelors and masters degree program is offered beginning fall 2006. This program is designed to provide selected highly accomplished undergraduate students with the opportunity to combine advanced undergraduate course work with graduate course work, and accelerate graduate degree completion. Students will be able to earn a BS and an MS degree in five years.

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 in embedded systems. 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 in many disciplines. The department strives to maintain a modern learning environment that fosters excellence, cooperation, and scholarship for faculty, students, and staff.

ADMISSION REQUIREMENTS

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. Students follow the first- and second-year sequence of courses listed in the curriculum outline for their particular major. Included in the first three semester schedules are all skill-set courses:

CSE	100	Principles of Programming with C++ *CS*	3
		or CSE 110 Principles of Programming with Java *CS* (3)	
CSE	101	Introduction to Engineering Design *CS**	3
CSE	120	Digital Design Fundamentals	3
CSE	205	Concepts of Computer Science and Data Structures *CS*	3
CSE	230	Computer Organization and Assembly Language Programming	3
MAT	243	Discrete Mathematical Structures	3
MAT	294	ST: Calculus for Engineers I	3
MAT	294	ST: Calculus for Engineers II	3
MAT	294	ST: Calculus for Engineers III	3
Total			27

* CSE 101 is for Computer Systems Engineering only.

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 93.

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 skill-set courses. All students seeking professional status must be in the process of completing all the skill-set 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 during enrollment periods at cse.asu.edu.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is required for the BS degree in Computer Science and the BSE degree in Computer Systems Engineering. A minimum of 45 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 89.

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 CSE Advising Center, call 480/965-3199, 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)

First-year composition subtotal 6

General Studies/Department Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

HU/SB electives 18

Literacy and Critical Inquiry

Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major

Natural Sciences/Basic Sciences

BIO 187 General Biology I *SG* 4
or 188 General Biology II *SQ* (4)
Lab Science I[1] 4
Lab Science II[1] 4

Natural sciences/basic sciences subtotal 12

Mathematical Studies

IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAT 243 Discrete Mathematical Structures[2] 3
MAT 294 ST: Calculus for Engineers I[2] 3
MAT 294 ST: Calculus for Engineers II[2] 3
MAT 294 ST: Calculus for Engineers III[2] 3
MAT 343 Applied Linear Algebra 3

Mathematical studies subtotal 18

General Studies/department requirements total 48

Computer Science Major Curriculum

Computer Science Core

CSE 100 Principles of Programming with C++ *CS*[2] 3
or CSE 110 Principles of Programming with Java *CS* (3)[2]
CSE 120 Digital Design Fundamentals[2] 3
CSE 205 Concepts of Computer Science and Data Structures *CS*[2] 3
CSE 230 Computer Organization and Assembly Language Programming[2] 3
CSE 240 Introduction to Programming Languages 3
CSE 301 Computing Ethics 1
CSE 310 Data Structures and Algorithms 3
CSE 340 Principles of Programming Languages 3
CSE 355 Introduction to Theoretical Computer Science 3
CSE 360 Introduction to Software Engineering 3
CSE 430 Operating Systems 3
CSE 485 Computer Science Capstone Project I *L* 3
CSE 486 Computer Science Capstone Project II 3

Computer science core subtotal 37

Electives

400-level CSE computer science breadth requirement[3] 15
General electives 8

Technical electives[4] 6
Electives subtotal 29
Total degree requirements 120

[1] A biology, chemistry, or physics two-course sequence meets the requirement.
[2] Computer Science and Engineering skill-set courses must be completed in order to be admitted to the professional program.
[3] Students cannot count toward graduation more than six semester hours of independent study courses, including, but not limited to, CSE 484, 492, 493, and 499. Computer science honors students are allowed to use an extra three semester hours for the L elective. The only course that meets the L elective requirement in this group is CSE 493.
[4] Each student must complete six hours of courses chosen from the computer science technical elective list and approved by the student's advisor. See an advisor for the approved listing.

Computer Science
Program of Study
Typical Four-Year Sequence

First Year

First Semester
CSE 100 Principles of Programming with C++ *CS* 3
or 110 Principles of Programming with Java *CS* (3)
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
HU/SB and awareness area course* 3
General elective 3
Total 15

Second Semester
BIO 187 General Biology I *SG* 4
or BIO 188 General Biology II *SQ* (4)
CSE 120 Digital Design Fundamentals 3
CSE 205 Concepts of Computer Science and Data Structures *CS* 3
ENG 102 First-Year Composition 3
MAT 294 ST: Calculus for Engineers II 3
Total 16

Second Year

First Semester
CSE 230 Computer Organization and Assembly Language 3
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAT 243 Discrete Mathematical Structures 3
MAT 294 ST: Calculus for Engineers III 3
HU/SB and awareness area course* 3
Total 15

Second Semester
CSE 240 Introduction to Programming Languages 3
MAT 343 Applied Linear Algebra 3
HU/SB and awareness area course* 3
Laboratory Science *SQ* 4
Total 13

Third Year

First Semester
CSE 310 Data Structures and Algorithms 3
CSE 360 Introduction to Software Engineering 3
HU/SB and awareness area course* 3
Laboratory Science II *SQ* 4
General elective 3
Total 16

Second Semester
CSE 301 Computing Ethics 1
CSE 340 Principles of Programming Languages 3
CSE 355 Introduction to Theoretical Computer Science 3
400-level CSE Computer Science breadth elective 3
HU/SB and awareness area course* 3
Technical elective 3
Total 16

Fourth Year

First Semester
CSE 430 Operating Systems 3
CSE 485 Computer Science Capstone I *L* 3
400-level CSE Computer Science breadth electives 6
General elective 2
Total 14

Second Semester
CSE 486 Computer Science Capstone II *L* 3
400-level CSE Computer Science breadth electives 6
HU/SB and awareness area course* 3
Technical elective 3
Total 15

Total degree requirements 120

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

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 Consortium for Embedded Systems. Students who participate in this internship program receive academic credit (CSE 484) that applies to the technical elective requirement of the BSE degree in Computer Systems Engineering. The following table specifies departmental requirements for the BSE degree in Computer Systems Engineering.

First-Year Composition
Choose among the course combinations below 6
ENG 101 First-Year Composition (3)
ENG 102 First-Year Composition (3)
———*or*———
ENG 105 Advanced First-Year Composition (3)
HU/SB elective chosen with an advisor (3)
———*or*———
ENG 107 English for Foreign Students (3)
ENG 108 English for Foreign Students (3)
First-year composition subtotal 6

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 93.

General Studies/Department Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

HU/SB electives 15

Total 15

Literacy and Critical Inquiry

Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

BIO 187 General Biology I *SG* 4
or 188 General Biology II SQ (4)
PHY 121 University Physics I: Mechanics *SQ*[1] 3
PHY 122 University Physics Laboratory I *SQ*[1] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ* [2] 3
PHY 132 University Physics Laboratory II *SQ*[2] 1

Natural sciences/basic sciences subtotal 12

Mathematical Studies

MAT 243 Discrete Mathematical Structures[3] 3
MAT 275 Modern Differential Equations *MA*[3] 3
MAT 294 ST: Calculus for Engineers I[3] 3
MAT 294 ST: Calculus for Engineers II[3] 3
MAT 294 ST: Calculus for Engineers III[3] 3

Mathematical studies subtotal 15

General Studies/department requirement total 42

Courses in Major

Lower-Division Engineering

CSE 100 Principles of Programming with C++ *CS*[3] 3
or CSE 110 Principles of Programming with Java *CS* (3)[3]
CSE 101 Introduction to Engineering Design *CS*[3] 3
CSE 120 Digital Design Fundamentals[3] 3
CSE 205 Concepts of Computer Science and Data Structures *CS*[3] 3
CSE 220 Programming for Computer Engineering[3] 3
CSE 230 Computer Organization and Assembly Language Programming[3] 3
EEE 202 Circuits I 4
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3

Lower-division subtotal 25

Upper-Division Courses in Major

CSE 301 Computing Ethics 1
CSE 310 Data Structures and Algorithms 3
CSE 320 Design and Synthesis of Digital Hardware 3
CSE 325 Embedded Microprocessor Systems 3
CSE 360 Introduction to Software Engineering 3
CSE 420 Computer Architecture I 3
CSE 423 Systems Capstone Project I *L* 3
CSE 424 Systems Capstone Project II 3
CSE 430 Operating Systems 3
CSE 434 Computer Networks 3
EEE 334 Circuits II 4
MAT 343 Applied Linear Algebra 3
Technical electives[4] 12

Upper-division subtotal 47

Total degree requirements 120

[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] Computer Science and Engineering skill-set courses must be completed in order to be admitted to professional programs.

[4] Each student must complete 12 hours of courses chosen from the computer science technical elective list and approved by the student's advisor. See an advisor for the approved listing.

Computer Systems Engineering
Program of Study
Typical Four-Year Sequence

First Year

First Semester

CSE 100 Principles of Programming with C++ *CS* 3
or CSE 110 Principles of Programming with Java *CS* (3)
CSE 101 Introduction to Engineering Design *CS* 3
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3
HU/SB and awareness area course[1] 3

Total 15

Second Semester

BIO 187 General Biology I *SG* 4
or BIO 188 General Biology II *SQ* (4)
CSE 120 Digital Design Fundamentals 3
CSE 205 Concepts of Computer Science and Data Structures *CS* 3
ENG 102 First-Year Composition 3
MAT 294 ST: Calculus for Engineers II 3

Total 16

Second Year

First Semester

CSE 230 Computer Organization and Assembly Language Programming 3
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAT 243 Discrete Mathematical Structures 3
MAT 294 ST: Calculus for Engineers III 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1

Total 16

Second Semester

CSE 220 Programming for Computer Engineering 3
MAT 275 Modern Differential Equations *MA* 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3] 3
PHY 132 University Physics Laboratory II *SQ*[3] 1
HU/SB and awareness area course[1] 3

Total 13

Third Year

First Semester

CSE 301 Computing Ethics 1
CSE 310 Data Structures and Algorithms 3
CSE 360 Introduction to Software Engineering 3
EEE 202 Circuits I 4
HU/SB and awareness course[1] 3

Total 14

Second Semester

CSE 320 Design and Synthesis of Digital Hardware 3
CSE 325 Embedded Microprocessor Systems 3
EEE 334 Circuits II 4
MAT 343 Applied Linear Algebra 3
HU/SB and awareness area course[1] 3

Total 16

Fourth Year

First Semester

CSE 423 Systems Capstone Project I *L*	3
CSE 430 Operating Systems	3
CSE Technical electives	6
HU/SB and awareness area course[1]	3
Total	15

Second Semester

CSE 424 Systems Capstone Project II	3
CSE 420 Computer Architecture	3
CSE 434 Computer Networks	3
Technical electives	6
Total	15

Total degree requirements 120

[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.

COMPUTER SCIENCE AND ENGINEERING (CSE)

For more CSE courses, see the "Course Prefixes" table, or access www.asu.edu/aad/catalogs/courses. The campus designation—D (Downtown Phoenix), E (Polytechnic), M (Tempe), or W (West)—may affect how courses may be used to fulfill requirements.

M 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

M CSE 101 Introduction to Engineering Design. (3)
fall and spring
Introduces engineering design, teaming, engineering profession; computer models and programming; communication skills; design of electrical and computer-based systems. Lecture, lab. Cross-listed as EEE 101. Credit is allowed for only CSE 101 or EEE 101. Fee. Prerequisites: high school algebra, computing, and physics courses (or their equivalents).
General Studies: CS

M 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

M CSE 120 Digital Design Fundamentals. (3)
fall and spring
Number systems, conversion methods, binary and complement arithmetic, Boolean algebra, circuit minimization, ROMs, PLAs, flipflops, synchronous sequential circuits. Lecture, lab. Cross-listed as EEE 120. Credit is allowed for only CSE 120 or EEE 120. Fee. Prerequisite: computer literacy.

M 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

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

M CSE 182 Applied Problem Solving with C#.Net. (3)
fall and spring
Introduces object oriented programming, problem solving, fundamental algorithms and techniques, computer systems concepts, and implementation of programs using Visual C#.Net platform.

M 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.

M CSE 205 Concepts of Computer Science and Data Structures. (3)
fall and spring
Problem solving by programming with an object-oriented programming language. Introduction to data structures. Overview of computer science topics. Fee. Prerequisite: CSE 100 or 110 or instructor approval.
General Studies: CS

M 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 205.
General Studies: CS

M CSE 220 Programming for Computer Engineering. (3)
fall and spring
Introduces procedure programming languages (C/C++) and hardware descriptive language (VHDL). Fee. Prerequisites: CSE 120 (or EEE 120), 205.

M CSE 230 Computer Organization and Assembly Language Programming. (3)
fall and spring
Register-level computer organization. Instruction set architecture. Assembly language. Processor organization and design. Memory organization. IO programming, Exception/interrupt handling. Cross-listed as EEE 230. Credit is allowed for only CSE 230 or EEE 230. Fee. Prerequisites: CSE 100 (or 110), 120 (or EEE 120).

M 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 205.

M CSE 301 Computing Ethics. (1)
fall and spring
Offers broad coverage of computing ethics topics, including: computing history, philosophical frameworks, intellectual property, privacy, and professional responsibilities. Prerequisite: CSE 220 or 240.

M 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. Fee. Lecture, lab. Prerequisites: CSE 220 (or 240); MAT 243.

M CSE 320 Design and Synthesis of Digital Hardware. (3)
fall and spring
Design and synthesis of digital hardware with hardware description language, computer-aided design tools, and programmable devices. Fee. Prerequisites: CSE 220, 230 (or EEE 230).

M CSE 325 Embedded Microprocessor Systems. (3)
fall and spring
System-level programming and analysis of embedded microprocessors systems. Fundamental concepts of digital system design for embedded system applications. Fee. Prerequisites: CSE 220, 230 (or EEE 230).

M 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.

M CSE 340 Principles of Programming Languages. (3)
fall and spring
Formal syntactic and semantic descriptions, compilation and implementation issues, and theoretical foundations for several programming paradigms. Formal syntactic and semantic descriptions, compilation and implementation issues, and theoretical foundations for several programming paradigms. Prerequisites: CSE 230, 310.

M 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.

M CSE 360 Introduction to Software Engineering. (3)
fall and spring
Software life cycle models; project management, team development environments and methodologies; software architectures; quality assurance and standards; legal, ethical issues. Fee. Prerequisite: CSE 220 or 240.

M 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.

M 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.

M CSE 414 Advanced Database Concepts. (3)
fall and spring
Object-oriented data modeling, advanced relational features, JDBC and Web access to databases, XML and databases, object-oriented databases, and object-relational databases. Prerequisite: CSE 412.

M CSE 420 Computer Architecture I. (3)
fall, spring, summer
Computer architecture. Performance versus cost tradeoffs. Instruction set design. Basic processor implementation and pipelining. Prerequisite: CSE 230.

M 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.

M 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.

M CSE 423 Systems Capstone Project I. (3)
fall and spring
Development process: specification, design, implementation, evaluation, and testing with economic, social, and safety considerations. Technical communication and team skills enrichment. Fee. Prerequisites: CSE 320, 325, 360.
General Studies: L

M CSE 424 Systems Capstone Project II. (3)
fall and spring
Continuation of capstone project started in CSE 423. Fee. Prerequisite: CSE 423.
General Studies: L

M CSE 428 Computer-Aided Processes. (3)
selected semesters
Hardware and software considerations for computerized manufacturing systems. Specific concentration on automatic inspection, numerical control, robotics, and integrated manufacturing systems. Prerequisite: CSE 330.

M 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 230 (or EEE 230), 310.

M 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. Fee. Prerequisite: CSE 430.

M CSE 434 Computer Networks. (3)
fall and spring
Distributed computing paradigms and technologies, distributed system architectures and design patterns, frameworks for development of distributed software components. Prerequisite: CSE 230 or EEE 230.

M CSE 438 Systems Programming. (3)
selected semesters
Design and implementation of systems programs, including text editors, file utilities, monitors, assemblers, relocating linking loaders, I/O handlers, and schedulers. Prerequisite: CSE 421 or instructor approval.
General Studies: L

M 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.

M CSE 445 Distributed Software Development. (3)
fall and spring
Distributed computing paradigms and technologies, distributed system architectures and design patterns, frameworks for development of distributed software components. Fee. Lecture, projects. Prerequisite: CSE 360.

M 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.

M 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.

M CSE 457 Theory of Formal Languages. (3)
selected semesters
Theory of grammar, methods of syntactic analysis and specification, types of artificial languages, relationship between formal languages, and automata. Prerequisite: CSE 355.

M CSE 459 Logic for Computing Scientists. (3)
selected semesters
Propositional logic, syntax and semantics, proof theory versus model theory, soundness, consistency and completeness, first order logic, logical theories, automated theorem proving, ground resolution, pattern matching unification and resolution, Dijkstras logic, proof obligations, and program proving. Prerequisite: CSE 355.

M 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.

M 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. Fee. Lecture, lab. Prerequisite: CSE 460.
General Studies: L

M 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. Fee. Prerequisite: CSE 461. Pre- or corequisite: CSE 445.
General Studies: L

M CSE 463 Introduction to Human Computer Interaction. (3)
spring
Design, evaluate, and implement interactive software intended for human use. Prerequisite: CSE 310.

M CSE 465 Introduction to Information Assurance. (3)
fall or spring
Concepts of information assurance (IA); basic IA techniques, policies, risk management, administration, legal and ethics issues. Prerequisite: CIS 300 or CSE 360 or IEE 305.

M CSE 470 Computer Graphics. (3)
once a year
Introduces basic concepts of interactive computer graphics, realistic rendering, and 3-D viewing. Fee. Prerequisites: both CSE 310 and MAT 343 or only instructor approval.

M 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.

M CSE 476 Introduction to Natural Language Processing. (3)
selected semesters
Principles of computational linguistics, formal syntax, and semantics, as applied to the design of software with natural (human) language I/O. Prerequisite: CSE 310 or instructor approval.

M CSE 477 Introduction to Computer-Aided Geometric Design. (3)
once a year
Introduces basic concepts of 3-D computer geometry, including curves, surfaces, meshes. Prerequisites: both CSE 470 and MAT 343 or only instructor approval.

M CSE 484 Internship. (1–12)
selected semesters

M CSE 485 Computer Science Capstone Project I. (3)
fall and spring
First course in capstone sequence for computer science majors emphasizing development process, technical skills, teamwork, and communication. Fee. Prerequisites: CSE 310, 340, 360.
General Studies: L

M CSE 486 Computer Science Capstone Project II. (3)
fall and spring
Second course in capstone sequence for computer science majors continuing the development process, technical skills, teamwork, and communication. Fee. Prerequisite: CSE 485.
General Studies: L

M CSE 492 Honors Directed Study. (1–6)
selected semesters

M CSE 493 Honors Thesis. (1–6)
selected semesters

M 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.

M 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/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.

Department of Electrical Engineering

fulton.asu.edu/ee
480/965-3424
ENGRC 552

Stephen M. Phillips, Chair

Regents' Professors: Balanis, Ferry, Heydt

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

Associate Professors: Aberle, Allee, Bakkaloglu, Clark, Cochran, Dengi, Diaz, Duman, Holbert, Karam, Papandreou-Suppappola, Reisslein, Skromme, Tylavsky, J. Zhang

Assistant Professors: Abbaspour-Tamijani, Ayyanar, Barnaby, Cao, Chae, Jalali-Farahani, Joo, O'Brien, Qian, Tepedelenlioglu, Thornburg, Vasileska, Yu

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

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 93.

the necessary breadth of knowledge, the Electrical Engineering curriculum includes basic engineering courses and courses in 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 classes in chemistry, mathematics, and physics. The curriculum includes a number of required electrical engineering and technical elective courses. Approved technical elective courses provide students with an opportunity either to broaden their background in electrical engineering or to study, in greater depth, technical subjects in which they have special interests. Successful completion of the curriculum leaves the student prepared to embark on a career in electrical engineering or to pursue an advanced education in graduate school.

The engineering design experience is structured around three backbone courses employing engineering teams: EEE 101 Introduction to Engineering Design, EEE 488 Senior Design Laboratory I, and EEE 489 Senior Design Laboratory II. The integrated experience is strengthened with required courses and area pathway courses. 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.

ADMISSION REQUIREMENTS

Preprofessional Program (Lower Division). Most new freshman and all new transfer students eligible for admission to the Fulton School of Engineering who have been admitted to the university and who have selected Electrical Engineering as their major are admitted to the lower-division preprofessional program without separate application to the Department of Electrical Engineering. A separate application procedure is required for entry to the upper-division professional program. The preprofessional student follows the first- and second-year course sequence outlined in the typical four-year sequence, which includes all the skill-set courses required for promotion to the professional program. Transfer credits are not applied to this degree program or skill-set courses until they are reviewed and accepted by the director for undergraduate programs. Completion of lower-division requirements does not ensure acceptance to the upper-division program. Preprofessional students are not allowed to register for 300- and 400-level engineering courses. The required skill-set courses follow:

Required Skill-Set

CHM	114	General Chemistry for Engineers *SQ*	4
		or CHM 116 General Chemistry II *SQ*[1] (4)	
		or CHM 231 Elementary Organic Chemistry *SQ*[2] (3) and CHM 235 Elementary Organic Chemistry Laboratory *SQ*[2] (1)	
CSE	100	Principles of Programming with C++ *CS*[3]	3
EEE	101	Introduction to Engineering Design *CS*	3
EEE	120	Digital Design Fundamentals	3
EEE	202	Circuits I	4
MAT	274	Elementary Differential Equations *MA*[4]	3
		or MAT 275 Modern Differential Equations *MA*[4] (3)	
MAT	294	ST: Calculus for Engineers I[4]	3
MAT	294	ST: Calculus for Engineers II[4]	3
MAT	294	ST: Calculus for Engineers III[4]	3
PHY	121	University Physics I: Mechanics *SQ*[4, 5]	3
PHY	122	University Physics Laboratory I *SQ*[4, 5]	1
PHY	131	University Physics II: Electricity and Magnetism *SQ*[4, 6]	3
PHY	132	University Physics Laboratory II *SQ*[4, 6]	1
Required skill-set total			37

[1] CHM 116 has a prerequisite of CHM 113, which cannot be used for degree credit.

[2] Both CHM 231 and 235 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] A minimum grade of "C" (2.00) is required.

[5] Both PHY 121 and 122 must be taken to secure SQ credit.

[6] Both PHY 131 and 132 must be taken to secure SQ credit.

Professional Program (Upper Division). Admission to the upper-division professional program is competitive. Admission is awarded to those applicants demonstrating the highest promise for professional success. Transfer students who have completed the equivalent required lower-division skill-set courses may apply to the upper-division program. Prior attendance at ASU is not required for application to the upper-division program.

Consideration for promotion is not automatic. To be considered for admission to the upper-division program, the following requirements must be met:

1. admission to the ASU preprofessional Electrical Engineering program (note that application and admission to the upper-division professional program are separate from application and admission to ASU);
2. submission of a completed Application for Electrical Engineering Professional Program before the posted deadline (for admission criteria, deadlines, and an application, access the department's Web site at ful-

ton.asu.edu/ee/students/undergraduate/AdmissionRequirements.php); and

3. completion of all required lower-division skill-set courses, or equivalents, with a competitive GPA in the skill-set courses (note that completion of lower-division requirements does not ensure acceptance to the upper-division program).

Students are strongly encouraged to visit the Electrical Engineering advising office, ERC 555, at the beginning of the semester in which they wish to apply for the professional program to obtain information regarding admission criteria and application deadlines and procedures.

Students not admitted to the upper-division program are not dismissed from the Fulton School and may transfer to other programs. Students considering a change of major are encouraged to meet with an advisor in the program they wish to pursue to determine the likelihood of being promoted to the professional level.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Electrical Engineering. A minimum of 45 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 group of courses designated as major in the curriculum.

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 89.

COURSE REQUIREMENTS

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

First-Year Composition[1]

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)

First-year composition total 6

General Studies/Program Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN 211 Macroeconomic Principles *SB* 3
or ECN 212 Microeconomic Principles *SB* (3)
HU courses 6–9
SB course(s) 3–6
HU, SB Minimum subtotal 15

Literacy and Critical Inquiry

Six hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

BME 111 Engineering Perspectives on Biological Systems 3
or BCH 361 Principles of Biochemistry[2] (3)
CHM 114 General Chemistry for Engineers *SQ* 4
or CHM 116 General Chemistry II *SQ*[3] (4)
or CHM 231 Elementary Organic Chemistry *SQ*[1] (3)
and CHM 235 Elementary Organic Chemistry Laboratory *SQ*[1] (1)
PHY 121 University Physics I: Mechanics *SQ*[1, 4, 6] 3
PHY 122 University Physics Laboratory I *SQ*[1, 4, 6] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[1, 4, 7] 3
PHY 132 University Physics Laboratory II *SQ*[1, 4, 7] 1
PHY 241 University Physics III[1] 3
Total 18

Mathematical Studies[1]

MAT 274 Elementary Differential Equations *MA*[4] 3
or MAT 275 Modern Differential Equations *MA*[4] (3)
MAT 294 ST: Calculus for Engineers I[4] 3
MAT 294 ST: Calculus for Engineers II[4] 3
MAT 294 ST: Calculus for Engineers III[4] 3
MAT 342 Linear Algebra 3
or MAT 343 Applied Linear Algebra (3)
Mathematical studies subtotal 15

General Studies/program requirements total 48

Electrical Engineering Major

CSE 100 Principles of Programming with C++ *CS*[4, 8] 3
EEE 101 Introduction to Engineering Design *CS*[4] 3
EEE 120 Digital Design Fundamentals[4] 3
EEE 202 Circuits I[4] 4
EEE 203 Signals and Systems I 3
EEE 230 Computer Organization and Assembly Language Programming 3
EEE 241 Fundamentals of Electromagnetics 3
EEE 334 Circuits II 4
EEE 350 Random Signal Analysis 3
EEE 488 Senior Design Laboratory I *L* 3
EEE 489 Senior Design Laboratory II *L* 3
Area pathway courses; select four from the following 16
- EEE 304 Signals and Systems II (4)
- EEE 333 Hardware Design Language and Programmable Logic (4)
- EEE 335 Analog and Digital Circuits (4)
- EEE 341 Engineering Electromagnetics (4)
- EEE 352 Properties of Electronic Materials (4)
- EEE 360 Energy Systems and Power Electronics (4)

Technical electives 15
Total 66

Total degree requirements 120

---

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

2 BCH 361 requires CHM 231 be taken as a prerequisite.

3 CHM 116 has a prerequisite of CHM 113, which cannot be used for degree credit.

4 This is a required skill-set course.

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 93.

[5] Both CHM 231 and 235 must be taken to secure SQ credit.
[6] Both PHY 121 and 122 must be taken to secure SQ credit.
[7] Both PHY 131 and 132 must be taken to secure SQ credit.
[8] 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 15 semester hours of technical electives. Qualified students may choose from approved graduate courses. Students must have a GPA of 3.00 or higher and approval of the dean to enroll in EEE graduate-level courses. With department approval, a maximum of one technical elective may be taken outside electrical engineering. Technical electives may be selected from one or more of the following areas.

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

Computer Engineering
CSE 420 Computer Architecture I....3
EEE 404 Real-Time DSP Systems....3

Controls
EEE 480 Feedback Systems....4
EEE 481 Computer-Controlled Systems....3

Electromagnetics
EEE 443 Antennas for Wireless Communications....3
EEE 445 Microwaves....4
EEE 448 Fiber Optics....4

Electronic Circuits
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 II *SQ*[1] (4)
or CHM 231 Elementary Organic Chemistry *SQ*[2] (3)
and CHM 235 Elementary Organic Chemistry Laboratory *SQ*[2] (1)
CSE 100 Principles of Programming with C++ *CS*[2, 4] 3
EEE 101 Introduction to Engineering Design *CS*[2] 3
ENG 101 First-Year Composition....3
MAT 294 ST: Calculus for Engineers I[2] 3
Total 16

Second Semester
BME 111 Engineering Perspectives on Biological Systems 3
or BCH 361 Principles of Biochemistry[5] (3)
EEE 120 Digital Design Fundamentals[2] 3
ENG 102 First-Year Composition....3
MAT 294 ST: Calculus for Engineers II[2] 3
PHY 121 University Physics I: Mechanics *SQ*[2, 6] 3
PHY 122 University Physics Laboratory I *SQ*[2, 6] 1
Total 16

Second Year

First Semester
EEE 202 Circuits I[2] 4
MAT 274 Elementary Differential Equations *MA*[2] 3
or MAT 275 Modern Differential Equations *MA*[2] (3)
MAT 294 ST: Calculus for Engineers III[2] 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[2, 7] 3
PHY 132 University Physics Laboratory II *SQ*[2, 7] 1
Total 14

Second Semester
EEE 203 Signals and Systems I....3
EEE 241 Fundamentals of Electromagnetics....3
MAT 342 Linear Algebra 3
or MAT 343 Applied Linear Algebra (3)
PHY 241 University Physics III....3
HU/SB and awareness area course[8] 3
Total 15

Third Year

First Semester
EEE 230 Computer Organization and Assembly Language Programming....3
EEE 334 Circuits II 4
EEE 350 Random Signal Analysis....3
Area pathway course....4
Total 14

Second Semester
ECN 211 Macroeconomic Principles *SB* 3
or ECN 212 Microeconomic Principles *SB* (3)
Area pathway courses 12
Total 15

Fourth Year

First Semester
EEE 488 Senior Design Laboratory I *L* 3
HU/SB and awareness area course[8] 6
Technical electives 6
Total 15

Second Semester
EEE 489 Senior Design Laboratory II *L* 3
HU/SB and awareness area course[8] 3
Technical electives 9
Total 15

Total degree requirements....120

[1] CHM 116 has a prerequisite of CHM 113, which cannot be used for degree credit.
[2] This is a required skill-set course.
[3] Both CHM 231 and 235 must be taken to secure SQ credit.
[4] CSE 110 Principles of Programming with Java (3) can be substituted for CSE 100 with Department of Electrical Engineering approval.

[5] BCH 361 requires CHM 231 be taken as a prerequisite.
[6] Both PHY 121 and 122 must be taken to secure SQ credit.
[7] Both PHY 131 and 132 must be taken to secure SQ credit.
[8] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to meet HU or SB requirements.

ELECTRICAL ENGINEERING (EEE)

M EEE 101 Introduction to Engineering Design. (3)
fall and spring
Introduces engineering design, teaming, engineering profession; computer models and programming; communication skills; design of electrical and computer-based systems. Lecture, lab. Cross-listed as CSE 101. Credit is allowed for only EEE 101 or CSE 101. Fee. Prerequisites: high school algebra, computing, and physics courses (or their equivalents).
General Studies: CS

M 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.

M EEE 202 Circuits I. (4)
fall and spring
Principles for analyzing linear and nonlinear circuits. Uses SPICE and MATLAB. Design and measurement of linear analog electrical systems. Lecture, lab. Fee. Prerequisite: EEE 101 (or its equivalent). Pre- or corequisites: MAT 274 (or 275); PHY 131, 132.

M EEE 203 Signals and Systems I. (3)
fall and spring
Introduces continuous and discrete time signal and system analysis, linear systems, Fourier, and z-transforms. Prerequisite: EEE 202. Pre- or corequisite: MAT 342 or 343.

M EEE 230 Computer Organization and Assembly Language Programming. (3)
fall and spring
Register-level computer organization. Instruction set architecture. Assembly language. Processor organization and design. Memory organization. IO programming, Exception/interrupt handling. Cross-listed as CSE 230. Credit is allowed for only EEE 230 or CSE 230. Fee. Prerequisites: CSE 100 (or 110), 120 (or EEE 120).

M EEE 241 Fundamentals of Electromagnetics. (3)
fall and spring
Vector analysis, differential operators, fourier analysis, scalar, vector fields, electro/magneto statics, time-varying fields, boundary value problems, dielectric, magnetic materials, Maxwell's equations. Prerequisites: EEE 202; MAT 272 (or 294 ST: Calculus for Engineers III), 274 (or 275); PHY 131, 132.

M EEE 302 Electrical Networks. (3)
fall and spring
Analyzes linear and nonlinear networks. Analytical and numerical methods. Pre- or corequisite: MAT 362.

M EEE 304 Signals and Systems II. (4)
fall and spring
Communication, signal processing, control systems, continuous, discrete transforms, sampling theorem, analog, digital modulation, filter design, signal processing applications, state space. Lecture, lab. Fee. Prerequisite: EEE 203.

M EEE 333 Hardware Design Languages and Programmable Logic. (4)
fall and spring
Develops digital logic with modern practices of hardware description languages. Emphasizes usage, synthesis of digital systems for programmable logic, VLSI. Lecture, lab. Fee. Prerequisites: EEE 101 (or its equivalent), 120 (or CSE 120).

M EEE 334 Circuits II. (4)
fall and spring
Design of analog and digital circuits. Diodes/BJTs/ Mosfets. Digital and analog circuit building blocks. Fundamentals of mixed signal circuits. Lecture, lab. Fee. Prerequisite: EEE 202.

M EEE 335 Analog and Digital Circuits. (4)
fall and spring
Analog, digital microelectronic circuits and systems. Gate sizing, timing analysis, sequential digital circuits. Amplifiers, multistage op-amps, A/D, D/A converters. Lecture, lab. Fee. Prerequisite: EEE 334.

M EEE 341 Engineering Electromagnetics. (4)
fall and spring
Time-varying electromagnetic fields, waves in homogeneous and stratified media, transmission lines, waveguides and cavity resonators, radiation and antennas. Lecture, lab. Fee. Prerequisites: EEE 203, 241.

M EEE 350 Random Signal Analysis. (3)
fall and spring
Probabilistic and statistical analysis as applied to electrical signals and systems. Pre- or corequisite: EEE 203.

M EEE 352 Properties of Electronic Materials. (4)
fall and spring
Schrodinger's wave equation, potential barrier problems, bonds of crystals, the band theory of solids, semiconductors, superconductor dielectric, and magnetic properties. Prerequisites: CHM 114 (or 116); EEE 241; PHY 241.

M EEE 360 Energy Systems and Power Electronics. (4)
fall and spring
Conventional and alternate energy sources for power systems, three-phase analysis, AC generators, transformers, induction, DC motors, power electronic speed control. Fee. Lecture, lab. Prerequisites: EEE 202, 241.

M EEE 404 Real-Time DSP Systems. (3)
spring
Digital signal processors, translating signals and systems concepts into real-time multimedia and communications applications, real-time algorithms. Lecture, lab. Prerequisites: EEE 203, 230 (or CSE 230).

M 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. Fee. Lecture, lab. Prerequisite: EEE 203.

M 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: EEE 335.

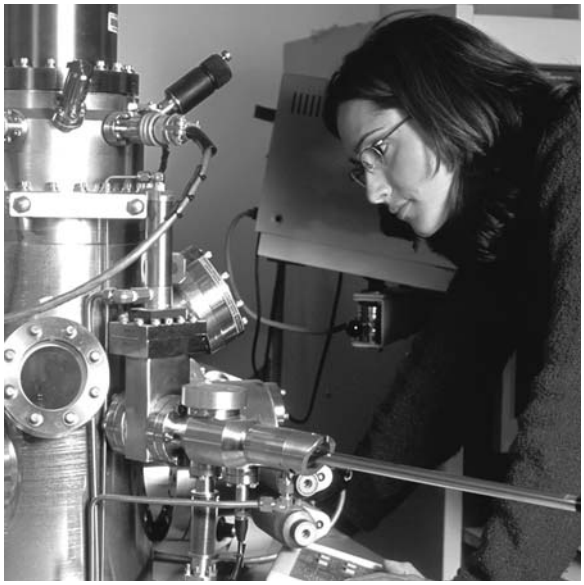
M EEE 433 Analog Integrated Circuits. (4)
fall and spring
Analysis, design, and applications of modern analog circuits using integrated bipolar and field-effect transistor technologies. Lecture, lab. Fee. Prerequisite: EEE 335.

M 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: EEE 241, 352.

M 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.

M 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: EEE 352.

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/ quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.



Hands-on experience is an important part of the engineering curriculum.

John Phillips photo

M 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.

M 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.

M 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 341.

M 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 341.

M EEE 448 Fiber Optics. (4)
fall
Principles of fiber-optic communications. Fee. Lecture, lab. Prerequisite: EEE 341.

M 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. Fee. Lecture, lab. Prerequisites: EEE 203, 350.

M EEE 459 Communication Networks. (3)
spring
Fundamentals of communication networks. Study of Seven-Layer OSI model. Focus on functionality and performance of protocols used in communication networks. Prerequisite: EEE 203. Pre- or corequisite: EEE 350.

M 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. Prerequisites: CHM 114 (or 116); MAT 274 (or 275); PHY 241 (or 361).

M 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: CHM 114 (or 116); MAE 240 (or PHY 241); MAT 274 (or 275).

M 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.

M 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.

M 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.

M 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. Fee. Lecture, lab. Prerequisite: EEE 203 or MAE 318.

M EEE 481 Computer-Controlled Systems. (3)
fall
Implements computer-based, embedded, control systems using MATLAB xPC Target toolbox. Small-scale, representative projects demonstrate theoretical issues and provide hands-on expertise. Prerequisites: both EEE 203 and 230 (or CSE 230) or only MAE 318.

M EEE 488 Senior Design Laboratory I. (3)
fall and spring
Design process: research, concept, feasibility, simulation, specifications, benchmarking, and proposal generation. Technical communications and team skills enrichment. Fee. Lecture, lab. Prerequisites: ENG 102 (or 105 or 108); EEE 241, 334, 350; four area pathway courses.
General Studies: L

M EEE 489 Senior Design Laboratory II. (3)
fall and spring
Implement, evaluate, and document EEE 488 design. Social, economic, and safety considerations. Technical communications and team skills enrichment. Fee. Lecture, lab. Prerequisite: EEE 488 in the immediately preceding semester.
General Studies: L

M EEE 492 Honors Directed Study. (1–6)
selected semesters

M EEE 493 Honors Thesis. (1–6)
selected semesters

M 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.

M 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/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.

Department of Industrial Engineering

fulton.asu.edu/ie
480/965-3185
GWC 502

Gary L. Hogg, Chair

Regents' Professor: Montgomery

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

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

Assistant Professors: Gel, Keha, Kulahci, Wu

Senior Lecturer: Thompson

Lecturer: Chattin

The industrial engineer (IE) provides leadership for organizations in establishing and maintaining competitiveness in the global marketplace through system integration and productivity improvement. 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 evaluates the total picture of productivity to make each system perform at its best with the right combination of human resources, natural resources, synthetic structures, and equipment. An IE bridges the gap between management and operations, working with and motivating people as well as determining what tools should be used and how they should be used.

INTEGRATION OF TECHNOLOGY AND PEOPLE

Industrial engineers are the "productivity people" who provide the necessary leadership and skills to integrate technology and people. No challenge can be greater than improving productivity, which is the application of knowledge and skills to provide improved goods and services that enhance quality of life. Such improvement must be achieved without waste of physical and human resources while maintaining environmental balance. This requires that IEs possess a wide range of interests and expertise to fulfill job responsibilities. To be competitive in the 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.

An IE deals with people as well as technology. In fact, industrial engineering is often called the "people-oriented profession" because the IE's primary function is to integrate people with technology-oriented systems. For this reason, IEs are active in the fields of ergonomics and human factors. Many industrial engineers will find themselves involved with interdisciplinary teams. IEs are often leaders of teams composed of electrical and mechanical engineers, accountants, computer scientists, and planners.

DIVERSE APPEAL OF INDUSTRIAL ENGINEERING

Skills in industrial engineering are applicable to every kind of organization. IEs learn how to approach, think about, and solve productivity and integration problems in diverse settings. They work in a variety of industries, including manufacturing facilities, banks, hospitals, government, transportation, construction, and social services. Within this wide range of organizations, IEs get involved in projects such as designing and implementing quality control systems, computer-based management information systems, and manufacturing operating systems.

IEs have a sound background in technology integration, management theory and application, engineering economics, and cost analysis. They are well equipped to deal with current organizational problems. As a matter of fact, more than half of all professional IEs are in management positions. Industrial engineers are prime candidates for promotion through the management career path, especially in high-tech organizations.

Industrial engineering students at the Fulton School of Engineering gain experience in the development and use of analytical tools. Students learn to understand the problems of clients and respond quickly because through the IE program, they have had the opportunity to develop first-rate analytical and people skills. These skills, when applied to the professional world, play a vital role for organizations competing in today's global marketplace.

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 focus study area electives, enabling each student to focus on a specific career objective.

Successful completion of this curriculum prepares the student to embark on a career in industrial engineering or to pursue advanced study in graduate school.

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 telecommunications systems*: for a career in the application of integrated computer and telecommunication systems to manufacturing and service systems analysis and design.
3. *Global industrial engineering leadership*: for a career in global manufacturing and service organizations.
4. *High-tech manufacturing*: for a career in the design and analysis of integrated manufacturing systems.

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 93.

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.

ADMISSION REQUIREMENTS

Preprofessional Program (lower-division courses). All students entering the Industrial Engineering program are admitted as preprofessional. The only exception to this is for students who qualify to be admitted directly into any Fulton School of Engineering professional program. All students are required to complete the first- and second-year sequence of lower-division courses. In addition, preprofessional students must take the following skill-set courses in order to be considered for admission to the professional program. The GPA for all skill-set courses must be 2.50 or higher.

Required Skill-Set

BME	111	Engineering Perspectives on Biological Systems[1]	3
CSE	110	Principles of Programming with Java *CS*[1]	3
ECN	211	Macroeconomic Principles *SB*	3
ENG	101	First-Year Composition[2]	3
		or ENG 105 Advanced First-Year Composition (3)	
		or ENG 107 English for Foreign Students (3)	
IEE	100	Introduction to Engineering Design for IE *CS*	3
MAT	294	ST: Calculus for Engineers I[1]	3
MAT	294	ST: Calculus for Engineers II[1]	3
PHY	121	University Physics I: Mechanics *SQ*[1, 3]	3
PHY	122	University Physics Laboratory I *SQ*[1, 3]	1
Required skill-set total			25

[1] The GPA for science and mathematics courses must be 2.50 or higher.

[2] A minimum grade of "C" (2.00) is required.

[3] Both PHY121 and 122 must be taken to secure SQ credit.

Professional Program. Students admitted to the professional program are eligible to take upper-division engineering courses. Students with applicable transfer credit will be evaluated based on the same GPA criteria for the skill-set courses. All students seeking professional status must be in the process of completing their skill-set courses in order to apply to the professional program. Please visit the academic advisor for details on applying to the professional program. Professional status will be granted once the skill-set courses and required grades are attained.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Industrial Engineering. A minimum of 45 upper-division hours is required. Students must attain a GPA of at least "C" (2.00) for each course in industrial engineering.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, students must satisfy all university graduation requirements. See "University Graduation Requirements," page 89. For information concerning admission, degree, course, and graduation requirements for the School of Engineering, see "Admission," page 372, and subsequent sections.

COURSE REQUIREMENTS

Students take 55 semester hours of university English proficiency and general studies course work, 26 semester hours of lower-division engineering courses, 24 semester hours of upper-division industrial engineering courses, three semester hours of industrial engineering upper-division electives, and 12 semester hours of career-focused study area electives of which at least nine are upper-division. Each career-focused study area has an associated list of recommended study area courses. A total of 45 semester hours of IE courses are included in the overall course requirements for the IE degree. 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[1, 2] (3)
- ENG 102 First-Year Composition[1] (3)

——— *or* ———

- ENG 105 Advanced First-Year Composition[1, 2] (3)
- Elective chosen with an advisor (3)

——— *or* ———

- ENG 107 English for Foreign Students[1, 2] (3)
- ENG 108 English for Foreign Students[1] (3)

First-year composition total 6

General Studies/Program Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN	211	Macroeconomic Principles *SB*[2]	3
HU electives			6–9
SB electives			3–6
Humanities and fine arts/social and behavioral sciences subtotal			15

Literacy and Critical Inquiry

Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences/Basic Sciences

BME	111	Engineering Perspectives on Biological Systems[2]	3
PHY	121	University Physics I: Mechanics *SQ*[2, 4]	3
PHY	122	University Physics Laboratory I *SQ*[2, 4]	1
PHY	131	University Physics II: Electricity and Magnetism *SQ*[5]	3
PHY	132	University Physics Laboratory II *SQ*[5]	1
Natural sciences/basic sciences subtotal			11

Mathematical Studies

IEE	280	Probability and Statistics for Engineering Problem Solving *CS*[1]	3
MAT	242	Elementary Linear Algebra	2
MAT	275	Modern Differential Equations *MA*	3
MAT	294	ST: Calculus for Engineers I[2]	3
MAT	294	ST: Calculus for Engineers II[2]	3
MAT	294	ST: Calculus for Engineers III	3
Mathematical studies subtotal			17
General studies/program requirement total			43

Major

Lower-Division Engineering Courses

CSE	110	Principles of Programming with Java *CS*[2]	3
CSE	205	Concepts of Computer Science and Data Structures *CS*	3

IEE 100 Introduction to Engineering Design for IE *CS*[1, 2] 3
IEE 210 Introduction to Industrial Engineering[1] 3
IEE 220 Business and Industrial Engineering[1] 3
MAE 212 Engineering Mechanics 4
or CEE 211 Engineering Mechanics: Statics and Dynamics (4)
MSE 250 Structure and Properties of Materials 3
EEE 202 Circuits I 4

Lower-division subtotal 26

Upper-Division Industrial Engineering Required Courses[1]
IEE 300 Economic Analysis for Engineers 3
IEE 305 Information Systems Engineering *CS* 3
IEE 368 Facilities Analysis and Design *L* 3
or IEE 369 Work Analysis and Design *L* (3)
IEE 376 Operations Research Deterministic Techniques/ Applications *CS* 3
IEE 385 Introduction to Engineering Probability *CS* 3
IEE 461 Production Control 3
IEE 470 Stochastic Operations Research 3
IEE 474 Quality Control *CS* 3
IEE 475 Simulating Stochastic Systems *CS* 3
IEE 490 Project in Design and Development *L* 3
Industrial engineering elective area[3] 3
Career-focused area electives[6] 12

Upper-division courses subtotal 45

Major total 71

Degree requirements total 120

1 A minimum grade of "C" (2.00) or higher is required for graduation.
2 This course is to be taken as part of skill-set.
3 For information about these electives, see "Industrial Engineering Elective Area," on this page.
4 Both PHY 121 and 122 must be taken to secure SQ credit.
5 Both PHY131 and 132 must be taken to secure SQ credit.
6 For information about these electives, see "Career-Focused Study Area Electives," on this page.

Industrial Engineering Elective Area. Students select three 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 (at least nine upper-division hours) from one of the following five career-focused study areas:

Industrial and Management Systems[1]
IEE 369 Work Analysis and Design *L*[2] 3
or IEE 368 Facilities Analysis and Design *L* (3)[2]
IEE 431 Engineering Administration[2] 3
IEE 437 Human Factors Engineering[2] 3
Any approved engineering or business elective 3

Information and Telecommunication Systems[1]
IEE 405 Developing Information Systems Applications[2] 3
Any approved upper-division Information and Telecommunications electives 9

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 elective 3

High-Tech Manufacturing
EEE 352 Properties of Electronic Materials 4
EEE 435 Microelectronics 3
EEE 436 Fundamentals of Solid-State Devices 3
MSE 353 Introduction to Materials Processing and Synthesis 3
MSE 441 Analysis of Materials Failures 3
MSE 470 Polymers and Composites 3

Preprofessional and Service Systems
Focus area courses[3] 12

1 Certain focus areas may require more than 12 semester hours due to course prerequisites.
2 A minimum grade of "C" (2.00) or higher is required for graduation.
3 A student desiring a focus area other than those listed is invited to create his or her own that concentrates on a professional service area. The student is expected to formulate a set of four courses (12 semester hours) that supports his or her career option. The student needs to submit a petition to the department that explains and supports the focus and the courses selected. The associate chair for undergraduate studies must approve the petition before the student begins study in the focus area. For more information, see the IE academic advisor.

Industrial Engineering
Program of Study
Typical Four-Year Sequence

First Year

First Semester
BME 111 Engineering Perspectives on Biological Systems 3
ENG 101 First-Year Composition 3
IEE 100 Introduction to Engineering Design for IE *CS* 3
MAT 294 ST: Calculus for Engineers I 3
HU/SB elective[1] 3

Total 15

Second Semester
CSE 110 Principles of Programming with Java *CS* 3
ECN 211 Macroeconomic Principles *SB* 3
ENG 102 First-Year Composition 3
MAT 294 ST: Calculus for Engineers II 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1

Total 16

Second Year

First Semester
IEE 210 Introduction to Industrial Engineering 3
IEE 220 Business and Industrial Engineering 3
MAT 242 Elementary Linear Algebra 2
MAT 294 ST: Calculus for Engineers III 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3] 3
PHY 132 University Physics Laboratory II *SQ*[3] 1

Total 15

Second Semester
CSE 205 Concepts of Computer Science and Data Structures *CS* 3

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/ quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.

IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAT 275 Modern Differential Equations *MA* 3
MSE 250 Structure and Properties of Materials 3
HU/SB elective[1] 3
Total 15

Third Year

First Semester
EEE 202 Circuits I 4
IEE 300 Economic Analysis for Engineers 3
IEE 305 Information Systems Engineering *CS* 3
MAE 212 Engineering Mechanics 4
or CEE 211 Engineering Mechanics: Statics and Dynamics (4)
Total 14

Second Semester
IEE 368 Facilities Analysis and Design *L* 3
or IEE 369 Work Analysis and Design *L* (3)
IEE 376 Operations Research Deterministic Techniques/ Applications *CS* 3
IEE 385 Introduction to Engineering Probability *CS* 3
HU/SB elective[1] 3
Focus area course 3
Total 15

Fourth Year

First Semester
IEE 470 Stochastic Operations Research 3
IEE 474 Quality Control *CS* 3
IEE 475 Simulating Stochastic Systems *CS* 3
HU/SB elective[1] 3
Focus area course 3
Total 15

Second Semester
IEE 461 Production Control 3
IEE 490 Project Design and Development *L* 3
IE Technical Elective 3
Focus area course 6
Total 15

Total degree requirements 120

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

INDUSTRIAL ENGINEERING (IEE)

M IEE 100 Introduction to Engineering Design for IE. (3)
fall and spring
Introduces industrial engineering design; teaming, the profession of engineering, computer models in engineering communication skills; quality and customer satisfaction. Integrated lecture/lab. Fee.
General Studies: CS

M 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: IEE 100.

M IEE 220 Business and Industrial Engineering. (3)
fall and spring
Introduces business for industrial engineers, including business/ financial structures, fundamentals of cost and accounting, role of business/engineering in society. Prerequisite: IEE 210.

M IEE 280 Probability and Statistics for Engineering Problem Solving. (3)
fall and spring or summer
Applications-oriented course with computer-based experience using statistical software for formulating and solving engineering problems. Fee. Integrated lecture/lab. Prerequisite: MAT 271 or 294 ST: Calculus for Engineers II.
General Studies: CS

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

M IEE 300 Economic Analysis for Engineers. (3)
fall and spring
Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Prerequisites: IEE 100; MAT 270 (or 294 ST: Calculus for Engineers I).

M 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 205.
General Studies: CS

M 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: MSE 250.

M 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.

M IEE 368 Facilities Analysis and Design. (3)
fall
Planning, analysis, and design of the tangible physical assets of the firm. Emphasizes facilities location, materials handling, automation, computer integration, and utilization of financial resources. Applications in diverse fields. Lecture, lab. Fee. Prerequisites: ENG 101; IEE 300.
General Studies: L

M IEE 369 Work Analysis and Design. (3)
spring
Planning, analysis, and design of methods of accomplishing work. Emphasizes human factors, work planning, methods analysis and design, and work measurement. Applications in diverse fields. Lecture, lab. Fee. Prerequisites: ENG 101; IEE 300.
General Studies: L

M 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 205; MAT 242.
General Studies: CS

M IEE 385 Engineering Statistics with Probability. (3)
fall and spring
Designing statistical studies for solutions to engineering problems. Methods include regression, design and analysis of experiments, and other statistical topics. Prerequisite: IEE 280.
General Studies: CS

M IEE 394 Special Topics. (1–4)
fall and spring
Covers topics of immediate or special interest to a faculty member and students.

M IEE 405 Developing Information Systems Applications. (3)
spring
Analysis and design of distributed information system applications using object and relational architectures. Integrated lecture/lab. Prerequisites: CSE 205; IEE 305.

M 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.

M 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.

M 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. Fee. Prerequisites: CSE 100 (or 110); IEE 376, 385.

M 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

M IEE 470 Stochastic Operations Research. (3)
fall and spring
Modeling and analysis with emphasis on stochastic operations research. Models for stochastic processes, including Markov chains, queueing and decision analysis. Prerequisites: IEE 280, 376.

M 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

M 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. Fee. Prerequisites: CSE 205; IEE 385.
General Studies: CS

M 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

M IEE 492 Honors Directed Study. (1–6)
selected semesters

M IEE 493 Honors Thesis. (1–6)
selected semesters

M IEE 494 Special Topics. (1–4)
fall and spring
Topics may include the following:
- Information Systems Development Tools. (3)

M IEE 499 Individualized Instruction. (1–3)
selected semesters

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

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

Department of Mechanical and Aerospace Engineering

fulton.asu.edu/mae
480/965-3291
ECG 346

Robert E. Peck, Chair

Aerospace Engineering

Professors: Chattopadhyay, Mignolet, Wie

Associate Professors: Lee, Wells

Assistant Professor: Mikellides

Mechanical Engineering

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

Associate Professors: Chen, McNeill, Peralta, Phelan,

Assistant Professors: Calhoun, Friesen, Posner

The Department of Mechanical and Aerospace Engineering houses two undergraduate programs: Aerospace Engineering and Mechanical Engineering. Both programs prepare students for immediate entry into professional employment in the engineering field or for graduate study. The curricula in Aerospace and Mechanical Engineering emphasize fundamental principles of mechanical and thermal sciences as well as contemporary tools of engineering practice.

The Aerospace Engineering and Mechanical Engineering programs at ASU are accredited by the

ENGINEERING ACCREDITATION COMMISSION
OF ABET
111 MARKET PLACE, SUITE 1050
BALTIMORE MD 21202-4012
410/347-7700

INTEGRATED BSE—MS PROGRAM

The Integrated BSE—MS is designed to provide selected high-achieving MAE undergraduate students with the opportunity to combine advanced undergraduate course work with graduate course work and to accelerate graduate degree completion. Up to nine semester hours of approved graduate-level course work taken as technical electives during the senior year may apply to both undergraduate and graduate degrees.

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 93.

The program is particularly suited for students with strong academic backgrounds who are motivated to pursue independent research. Participants will have an opportunity to work in a laboratory/research environment and to engage in theoretical and/or experimental work with faculty and doctoral student mentors. Students will showcase their research at both the undergraduate/graduate research symposia in the Fulton School, and they will be eligible for travel grants to present their work at national conferences.

A minimum of two semesters of full-time enrollment in MAE is required. Applications are normally submitted with two semesters remaining in the senior year. A minimum of 90 credit hours of course work applicable to the BSE degree with a cumulative GPA of 3.50 to 4.00 or higher must be completed before beginning the joint degree program.

Students must apply for admission to the program through the MAE department and the Division of Graduate Studies (DGS) by submitting an application for the joint BSE—MS program in Aerospace or Mechanical Engineering. Forms are available at the MAE Graduate Advising Office, ECG 339, or can be downloaded from the MAE Web site.

AEROSPACE ENGINEERING—BSE

The Aerospace Engineering curriculum is designed to provide students with an education in technological areas critical to the design and development of aerospace vehicles and systems. The program emphasizes aeronautical engineering with required courses covering aerodynamics, aerospace materials, aircraft structures, propulsion, flight mechanics, and stability and control. Required astronautics topics include orbital mechanics, attitude control, and rocket propulsion.

The Aerospace Engineering program offers incoming freshmen a degree track with emphasis in astronautics. Enrollment in the astronautics track is limited, and interested students should contact the advising office in the Department of Mechanical and Aerospace engineering. Students should refer to the Web site of the Department of Mechanical and Aerospace Engineering for the latest information regarding the new offerings.

The Aerospace Engineering program has four educational objectives, which describe the expected capabilities and achievements of graduates during the first several years following completion of the program. The objectives of the program are to

1. provide graduates with the ability to think in a critical and evaluative manner and to consider a broad perspective, in order to solve technical and non technical problems;
2. prepare professionally successful graduates who provide effective leadership, who act in an ethical manner and whose skills include the ability to communicate well and to work successfully within diverse groups;
3. provide the depth and breadth of engineering education that prepares graduates for employment in the aerospace engineering profession, admission to graduate programs in Aerospace engineering or a related field, or the pursuit of advanced education in other professional areas, such as business, law, or medicine; and
4. cultivate in our graduates a spirit of inventiveness, creativity, and entrepreneurship.

Students are prepared for a career in Aerospace Engineering by a thorough grounding in the fundamentals of mathematics and science, instruction in engineering sciences, and experience in engineering design, which is distributed throughout the curriculum. Students are encouraged to select elective general studies courses that complement the program's technical content and promote the program objectives.

DEGREE REQUIREMENTS

In order to attain the Bachelor of Science in Engineering in Aerospace Engineering degree, students must complete a minimum of 120 semester hours of course work, including 45 upper-division hours. In addition to those courses specifically required for a degree in Aerospace Engineering, students must fulfill all university First-Year Composition and General Studies requirements. The Ira A. Fulton School of Engineering does not permit the use of pass/fail courses 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.

ADMISSION TO THE PROFESSIONAL PROGRAM

Admission to the professional program in Aerospace Engineering is competitive, and the level of achievement necessary for promotion will be based on several factors, including the number of places available and the number of students requesting professional status in a given year. Students must complete, or be currently enrolled in, the courses in the Aerospace Engineering skill-set before making application to the professional program. Students may not enroll in upper-division courses in the Department of Mechanical and Aerospace Engineering until they are admitted to professional status.

For admission to professional status in Aerospace Engineering, a minimum grade of "C" (2.00) is required in all chemistry, mathematics, and physics courses, and in all courses in the skill-set. It is anticipated that a minimum GPA of approximately 2.80 in the skill-set and overall will be necessary for professional admission. Under no circumstances will students with a GPA lower than 2.50 (in the skill-set and overall) be considered for promotion to professional status in Aerospace Engineering.

The following courses make up the skill-set in Aerospace Engineering. Students must have completed these courses, or be enrolled in them, in order to apply to the professional program in the major. All skill-set courses are normally taken during the first three semesters of a typical four-year program in Aerospace Engineering.

CHM 114 General Chemistry for Engineers *SQ*.....4–5
or CHM 115 General Chemistry with Qualitative Analysis *SQ*[1] (5)
or CHM 116 General Chemistry II *SQ*[1] (4)
ENG 102 First-Year Composition.....3
or ENG 105 Advanced First-Year Composition (3)
or ENG 108 English for Foreign Students (3)

MAE 100 Introduction to Mechanical and Aerospace Engineering *CS* 3
MAE 212 Engineering Mechanics....4
MAT 275 Modern Differential Equations *MA*....3
MAT 294 ST: Calculus for Engineers II....3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[2] 3
PHY 132 University Physics Laboratory II *SQ*[2] 1

Total 24–25

[1] CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.
[2] Both PHY 131 and 132 must be taken to secure SQ credit.

GRADUATION REQUIREMENTS

In addition to achieving professional status in Aerospace Engineering and completing all required course work, students must earn a minimum GPA of 2.00 in the major and overall. A minimum grade of "C" (2.00) is required in all upper-division major courses. The department may require additional or remedial course work for students experiencing academic difficulties.

COURSE REQUIREMENTS

The following constitute specific course requirements for the Bachelor of Science in Engineering degree for Aerospace Engineering:

First-Year Composition[1]

Choose among the course combinations below 6
ENG 101 First-Year Composition (3)
ENG 102 First-Year Composition (3)[2]
——— *or* ———
ENG 105 Advanced First-Year Composition (3)[2]
Approved Elective (3)
——— *or* ———
ENG 107 English for Foreign Students (3)
ENG 108 English for Foreign Students (3)[2]

First-year composition subtotal....6

General Studies/Program Requirements[3]

Humanities and Fine Arts/Social and Behavioral Sciences
Humanities and Fine Arts Courses....6–9
Social and Behavioral Sciences 6–9

Humanities and fine arts/social and behavioral sciences subtotal 15

Literacy and Critical Inquiry
Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major.

Mathematical Studies[1]
MAE 100 Introduction to Mechanical and Aerospace Engineering *CS*[2] 3
MAT 275 Modern Differential Equations *MA*....3
MAT 294 ST: Calculus for Engineers I....3
MAT 294 ST: Calculus for Engineers II[2] 3
MAT 294 ST: Calculus for Engineers III 3
MAT 343 Applied Linear Algebra....3

Mathematical studies subtotal....18

Natural Sciences[1]
BME 111 Engineering Perspectives on Biological Systems 3
CHM 114 General Chemistry for Engineers *SQ*[2] 4–5
or CHM 115 General Chemistry with Qualitative Analysis *SQ*[4, 5] (5)
or CHM 116 General Chemistry II *SQ*[5] (4)
PHY 121 University Physics I: Mechanics *SQ*[6] 3
PHY 122 University Physics Laboratory I *SQ*[6] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[2, 7] 3
PHY 132 University Physics Laboratory II *SQ*[2, 7] 1

Natural sciences subtotal....15–16

General studies/program requirements total 48

Aerospace Engineering Major

Lower-Division
EEE 202 Circuits I....4
MAE 212 Engineering Mechanics[2] 4
MAE 213 Solid Mechanics....3
MAE 214 Computer-Aided Engineering I....1
MAE 240 Thermofluids I....4

Lower-division subtotal 16

Upper-Division[1]
MAE 313 Aircraft Dynamics and Control....3
MAE 318 Sensors and Controls....5
MAE 322 Mechanics of Materials....4
MAE 344 Fundamentals of Aerospace Design....3
MAE 360 Aerodynamics[8] 4
MAE 362 High-Speed Aerodynamics[8] 4
MAE 384 Numerical Methods for Engineers 3
MAE 400 Engineering Profession 3
MAE 415 Vibration Analysis....3
MAE 462 Space Vehicle Dynamics and Control 3
MAE 463 Propulsion 3
MAE 468 Aerospace Systems Design *L*....3
Technical electives 6

Upper-division subtotal....47

Aerospace major total 63

General elective[9] 3

Program total....120

[1] A minimum grade of "C" (2.00) is required.
[2] This is an aerospace engineering skill-set course; it must be completed before promotion can be considered. A minimum grade of "C" (2.00) is required.
[3] See "General Studies," page 93. Students are encouraged to select HU and SB courses to complement their technical program and to promote the program objectives. Suggested HU/SB courses are available from the Department of Mechanical and Aerospace Engineering.
[4] Students taking CHM 115 will receive 4 semester hours of credit toward the Aerospace Engineering degree.
[5] CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.
[6] Both PHY 121 and 122 must be taken to secure SQ credit.
[7] Both PHY 131 and 132 must be taken to secure SQ credit.
[8] Students must complete both MAE 360 and 362 to secure L credit.
[9] General electives must be taken for a letter grade (A to E). Courses that are remedial for or prerequisites for any course required for the BSE degree in Aerospace Engineering are not approved for use as the free elective. Students must receive prior approval from the department to of receive free elective credit.

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 93.

TECHNICAL ELECTIVES

Students must select two courses from the following list of technical electives. Students may, with prior approval of the advisor and department chair, select an alternative course that supports a specific career objective. Though in general both technical electives will be 300- or 400-level courses, at least one of them must have upper-division designation. Graduate courses are permitted for students with a GPA of 3.00 or higher and with the approval of the instructor, the advisor and the dean. Students with a GPA of 3.50 or higher may wish to consider the Integrated BSE—MS program when selecting technical electives.

IEE 300 Economic Analysis for Engineers
MAE 340 Thermofluids II
MAE 341 Mechanism Analysis and Design
MAE 351 Manufacturing Processes
MAE 372 Fluid Mechanics
MAE 404 Finite Elements in Engineering
MAE 406 CAD/CAM Applications in MAE
MAE 417 Control System Design
MAE 426 Design of Aerospace Structures
MAE 434 Internal Combustion Engines
MAE 435 Turbomachinery
MAE 455 Polymers and Composites
MAE 465 Rocket Propulsion
MAE 466 Rotary Wing Aerodynamics and Performance
MAE 469 Projects in Astronautics or Aeronautics
MAE 471 Computational Fluid Dynamics
MAT 421 Applied Computational Methods *CS*
MAT 423 Numerical Analysis I *CS*
MAT 425 Numerical Analysis II *CS*
MSE 440 Mechanical Properties of Solids
MSE 441 Analysis of Material Failures

TYPICAL FOUR-YEAR SEQUENCE

The following presents a typical schedule for students wishing to complete the BSE in Aerospace Engineering within four years. When selecting a semester course schedule, students should consider that most upper-division courses are taught only once per academic year. Students may not register for upper-division courses in the major until they are accepted into the professional program in Aerospace Engineering.

Aerospace Engineering Program of Study
Typical Four-Year Sequence

First Year

Fall Semester

CHM 114 General Chemistry for Engineers *SQ* 4–5
or CHM 115 General Chemistry with Qualitative Analysis *SQ*[1, 2] (5)
or CHM 116 General Chemistry II *SQ*[2] (4)
ENG 101 First-Year Composition....3
MAE 100 Introduction to Mechanical and Aerospace Engineering *CS*[3]....3
MAT 294 ST: Calculus for Engineers I....3
Total 13–14

Spring Semester

ENG 102 First-Year Composition[3]....3
MAT 275 Modern Differential Equations *MA*[3]....3
MAT 294 ST: Calculus for Engineers II[3]....3
PHY 121 University Physics I: Mechanics *SQ*[4]....3
PHY 122 University Physics Laboratory I *SQ*[4]....1
HU/SB elective[4]....3
Total 16

Second Year

Fall Semester

BME 111 Engineering Perspectives on Biological Systems....3
MAE 212 Engineering Mechanics[3]....4
MAT 294 ST: Calculus for Engineers III....3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[3, 6]....3
PHY 132 University Physics Laboratory II *SQ*[3, 6]....1
Total 14

Spring Semester

EEE 202 Circuits I....4
MAE 213 Solid Mechanics....3
MAE 214 Computer-Aided Engineering I....1
MAE 240 Thermofluids I....4
MAT 343 Applied Linear Algebra....3
Total 15

Third Year

Fall Semester

MAE 318 Sensors and Controls....5
MAE 322 Mechanics of Materials....4
MAE 360 Aerodynamics[7]....4
MAE 384 Numerical Methods for Engineers....3
Total 16

Spring Semester

MAE 313 Aircraft Dynamics and Control....3
MAE 344 Fundamentals of Aerospace Design....3
MAE 362 High-Speed Aerodynamics[7]....4
HU/SB electives[4]....6
Total 16

Fourth Year

Fall Semester

MAE 415 Vibration Analysis....3
MAE 462 Space Vehicle Dynamics and Control....3
MAE 463 Propulsion....3
HU/SB elective[5]....3
Technical elective....3
Total 15

Spring Semester

MAE 400 Engineering Profession....3
MAE 468 Aerospace Systems Design *L*....3
General elective....3
HU/SB elective[5]....3
Technical elective....3
Total 15

Total degree requirements....120

1 Students taking CHM 115 will receive 4 semester hours of credit toward the Aerospace Engineering degree.

2 CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.

3 This is an aerospace engineering skill-set course; it must be completed before promotion can be considered. A minimum grade of "C" (2.00) is required.

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

[5] Aerospace Engineering Students may not use ASE or MIS courses for general studies credit.
[6] Both PHY 131 and 132 must be taken to secure SQ credit
[7] Both MAE 360 and 362 must be completed to secure L credit.

MECHANICAL ENGINEERING—BSE

Mechanical Engineering is a creative, diverse discipline that draws upon a number of basic sciences to design, build and control the devices, machines, processes and systems that are the mainstay of modern industrialized society. The field involves the conversion of energy resources into mechanical work through various engines and power plants; the transmission of energy and power via devices such as heat exchangers, machine elements and actuators, and the efficient use of energy to perform a variety of beneficial tasks such as transportation, manufacturing, agriculture, environmental control, domestic chores, healthcare, and security. 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 Mechanical Engineering program has four educational objectives, which describe the expected capabilities and achievements of graduates during the first several years following completion of the program. The objectives of the program are to

1. provide graduates with the ability to think in a critical and evaluative manner and to consider a broad perspective, in order to solve technical and non technical problems;
2. prepare professionally successful graduates who provide effective leadership, who act in an ethical manner and whose skills include the ability to communicate well and to work successfully within diverse groups;
3. provide the depth and breadth of engineering education that prepares graduates for employment in the Mechanical engineering profession, admission to graduate programs in Mechanical engineering or a related field, or the pursuit of advanced education in other professional areas, such as business, law, or medicine; and
4. cultivate in our graduates a spirit of inventiveness, creativity and entrepreneurship.

Students are prepared for a career in Mechanical Engineering through a curriculum that includes study of the principles governing the use of energy; the principles of design, instruments, and control devices; and the application of these to the creative solution of practical modern problems. Students are encouraged to select elective general studies courses that complement the program's technical content and promote its objectives.

DEGREE REQUIREMENTS

In order to attain the Bachelor of Science in Engineering in Mechanical Engineering degree, students must complete a minimum of 120 semester hours of course work, including 45 upper-division hours. In addition to those courses specifically required for a degree in Mechanical Engineering, students must fulfill all university First-Year Composition and General Studies requirements. The Ira A. Fulton School of Engineering does not permit the use of pass/fail courses 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.

ADMISSION TO THE PROFESSIONAL PROGRAM

Admission to the professional program in Mechanical Engineering is competitive, and the level of achievement necessary for promotion is based on several factors, including the number of places available and the number of students requesting professional status in a given year. Students must complete, or be currently enrolled in, the courses in the Mechanical Engineering skill-set before making application to the professional program. Students may not enroll in upper-division courses in the Department of Mechanical and Aerospace Engineering until they are admitted to professional status.

For admission to professional status in Mechanical Engineering, a minimum grade of "C" (2.00) is required in all chemistry, mathematics, and physics courses, and in all courses in the skill-set. It is anticipated that a minimum GPA of approximately 2.80 in the skill-set and overall will be necessary for professional admission. Under no circumstances will students with a GPA lower than 2.50 (in the skill-set and overall) be considered for promotion to professional status in Mechanical Engineering.

The following courses make up the skill-set in Mechanical Engineering. Students must have completed these courses or be enrolled in them in order to apply to the professional program in the major. All skill-set courses are normally taken during the first three semesters of a typical four-year program in Mechanical Engineering.

CHM 114 General Chemistry for Engineers *SQ*.....4–5
or CHM 115 General Chemistry with Qualitative Analysis *SQ*[1] (5)
or CHM 116 General Chemistry II *SQ*[1] (4)
ENG 102 First-Year Composition.....3
or ENG 105 Advanced First-Year Composition (3)
or ENG 108 English for Foreign Students (3)
MAE 100 Introduction to Mechanical and Aerospace Engineering *CS*.....3
MAE 212 Engineering Mechanics.....4
MAT 275 Modern Differential Equations *MA*.....3
MAT 294 ST: Calculus for Engineers II.....3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[2].....3

L literacy and critical inquiry / **MA** mathematics / **CS** computer/statistics/quantitative applications / **HU** humanities and fine arts / **SB** social and behavioral sciences / **SG** natural science—general core courses / **SQ** natural science—quantitative / **C** cultural diversity in the United States / **G** global / **H** historical / See "General Studies," page 93.

PHY 132 University Physics Laboratory II *SQ*[2] 1

Total 24–25

[1] CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.

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

GRADUATION REQUIREMENTS

In addition to achieving professional status in Mechanical Engineering and completing all required course work, students must earn 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 following constitute specific course requirements for the Bachelor of Science in Engineering degree for Mechanical Engineering:

First-Year Composition[1]

Choose among the course combinations below 6

ENG 101 First-Year Composition (3)
ENG 102 First-Year Composition (3)[2]

——— *or* ———

ENG 105 Advanced First-Year Composition (3) [2]
Approved Elective (3)

——— *or* ———

ENG 107 English for Foreign Students (3)
ENG 108 English for Foreign Students (3) [2]

Total 6

General Studies/Program Requirements[3]

Humanities and Fine Arts/Social and Behavioral Sciences

Humanities and Fine Arts Courses.....6–9
Social and Behavioral Sciences 6–9

Humanities and fine arts/social and behavioral sciences subtotal 15

Literacy and Critical Inquiry

Six semester hours of literacy and critical inquiry credit is satisfied by courses in the major.

Mathematical Studies[1]

MAT 275 Modern Differential Equations *MA*[2] 3
MAT 294 ST: Calculus for Engineers I 3
MAT 294 ST: Calculus for Engineers II[2] 3
MAT 294 ST: Calculus for Engineers III 3
MAT 343 Applied Linear Algebra.....3

Mathematical studies subtotal.....15

Natural Sciences[1]

BME 111 Engineering Perspectives on Biological Systems 3
or BCH 361 Principles of Biochemistry (3)
CHM 114 General Chemistry for Engineers *SQ*[2] 4–5
or CHM 115 General Chemistry with Qualitative Analysis *SQ*[4, 5] (5)
or CHM 116 General Chemistry II *SQ*[4, 5] (4)
CHM 231 Elementary Organic Chemistry *SQ* 3
or CHM 240 Introduction to Physical Chemistry *CS* (3)
PHY 121 University Physics I: Mechanics *SQ*[6] 3
PHY 122 University Physics Laboratory I *SQ*[6] 1
PHY 131 University Physics II: Electricity and Magnetism *SQ*[2, 7] 3
PHY 132 University Physics Laboratory II *SQ*[2, 7] 1

Natural sciences subtotal.....18–19

General studies/program requirements total 48

Mechanical Engineering Major

Lower-Division

EEE 202 Circuits I.....4
MAE 100 Introduction to Mechanical and Aerospace Engineering *CS*[2] 3
MAE 212 Engineering Mechanics[2] 4
MAE 213 Solid Mechanics.....3
MAE 214 Computer-Aided Engineering I.....1
MAE 240 Thermofluids I.....4
MSE 250 Structure and Properties of Materials 3

Lower-division subtotal 22

Upper-Division[1]

MAE 318 Sensors and Controls.....5
MAE 322 Mechanics of Materials.....4
MAE 323 Computer-Aided Engineering II 1
MAE 340 Thermofluids II 3
MAE 342 Principles of Design.....3
MAE 343 Computer-Aided Engineering III 1
MAE 384 Numerical Methods for Engineers 3
MAE 400 Engineering Profession 3
MAE 488 Mechanical Engineering Design I.....3
MAE 489 Mechanical Engineering Design II 3
MAE 491 Experimental Mechanical Engineering *L*.....3
Technical electives[8].....12

Upper-division subtotal.....44

Mechanical engineering major total.....66

Program total.....120

[1] A minimum grade of "C" (2.00) is required.

[2] This is a mechanical engineering skill-set course; it must be completed before promotion can be considered. A minimum grade of "C" (2.00) is required.

[3] See "General Studies," page 93. Students are encouraged to select HU and SB courses to complement their technical program and to promote the program objectives. Suggested HU/SB courses are available from the Department of Mechanical and Aerospace Engineering.

[4] Students taking CHM 115 will receive four semester hours of credit toward the Mechanical Engineering degree.

[5] CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.

[6] Both PHY 121 and 122 must be taken to secure SQ credit.

[7] Both PHY 131 and 132 must be taken to secure SQ credit.

[8] Mechanical Engineering students must select upper-division technical electives.

Technical Electives

Students select four technical electives from among all upper-division courses offered in the Department of Mechanical and Aerospace Engineering that are not required for the major in mechanical engineering. Students may, with prior approval of the advisor and department chair, select an alternative course that supports a specific career objective. Normally, only one technical elective from outside the Department of Mechanical and Aerospace Engineering will be approved. Because a minimum of 45 upper-division hours are required for graduation, technical electives must be numbered 300 or above. Graduate courses are permitted for students with a GPA of 3.00 or higher and with the approval of the instructor, the advisor, and the dean. Students with a GPA of 3.50 or higher may wish to consider the Integrated BSE—MS program when selecting technical electives.

Typical Four-Year Sequence

The following presents a typical schedule for students wishing to complete the BSE in Mechanical Engineering within four years. When selecting a semester course schedule, students should consider that many upper-division courses in Mechanical and Aerospace Engineering are taught only once per academic year. Students may not register for upper-division courses in the major until they are accepted into the professional program in Mechanical Engineering.

Mechanical Engineering Program of Study
Typical Four-Year Sequence

First Year

Fall Semester

CHM	114	General Chemistry for Engineers *SQ*[1, 2] 4–5
		or CHM 115 General Chemistry with Qualitative Analysis *SQ*[3, 4] (5)
		or CHM 116 General Chemistry II *SQ*[4] (4)
ENG	101	First-Year Composition[2] 3
MAE	100	Introduction to Mechanical and Aerospace Engineering *CS*[1] 3
MAT	294	ST: Calculus for Engineers I[1, 2] 3
HU/SB elective[5]		3
Total		16–17

Spring Semester

ENG	102	First-Year Composition[1, 2] 3
MAT	275	Modern Differential Equations MA[1, 2] 3
MAT	294	ST: Calculus for Engineers II[1, 2] 3
PHY	121	University Physics I: Mechanics *SQ*[6] 3
PHY	122	University Physics Laboratory I *SQ*[6] 1
HU/SB elective[5]		3
Total		16

Second Year

Fall Semester

CHM	231	Elementary Organic Chemistry *SQ* 3
		or CHM 240 Introduction to Physical Chemistry *CS* (3)
MAE	212	Engineering Mechanics[1] 4
MAT	294	ST: Calculus for Engineers III[2] 3
PHY	131	University Physics II: Electricity and Magnetism *SQ*[1, 2, 7] 3
PHY	132	University Physics Laboratory II *SQ*[1, 2, 7] 1
Total		14

Spring Semester

MAE	213	Solid Mechanics 3
MAE	214	Computer-Aided Engineering I 1
MAE	240	Thermofluids I 4
MAT	343	Applied Linear Algebra 3
MSE	250	Structure and Properties of Materials 3
Total		14

Third Year

Fall Semester

EEE	202	Circuits I 4
MAE	322	Mechanics of Materials 4
MAE	323	Computer-Aided Engineering II 1
MAE	340	Thermofluids II 3
MAE	384	Numerical Methods for Engineers 3
Total		15

Spring Semester

BME	111	Engineering Perspectives on Biological Systems 3
		or BCH 361 Principles of Biochemistry (3)
MAE	318	Sensors and Controls 5
MAE	342	Principles of Design 3
MAE	343	Computer-Aided Engineering III 1
Technical elective		3
Total		15

Fourth Year

Fall Semester

MAE	488	Mechanical Engineering Design I 3
MAE	491	Experimental Mechanical Engineering *L* 3
HU/SB elective[5]		3
Technical electives		6
Total		15

Spring Semester

MAE	400	Engineering Profession 3
MAE	489	Mechanical Engineering Design II 3
HU/SB electives[5]		6
Technical elective		3
Total		15

Total degree requirements 120

1 This is a mechanical engineering skill-set course; it must be completed before promotion can be considered. A minimum grade of "C" (2.00) is required.

2 A minimum grade of "C" (2.00) is required.

3 Students taking CHM 115 will receive four semester hours of credit toward the Mechanical Engineering degree.

4 CHM 115 and 116 have a prerequisite of CHM 113, which cannot be used for degree credit.

5 Aerospace Engineering Students may not use ASE or MIS courses for general studies credit.

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

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

MECHANICAL AND AEROSPACE ENGINEERING (MAE)

M MAE 100 Introduction to Mechanical and Aerospace Engineering. (3)
fall and spring
Introduces mechanical and aerospace engineering, design process, teaming, the profession of mechanical and aerospace engineering, computer models in engineering, communication skills, CAD tools, and programming tools. Fee. Prerequisites: high school algebra and physics; familiarity with computer applications.
General Studies: CS

M MAE 191 First-Year Seminar. (1–3)
selected semesters
Discussion of and critical thinking about topics of current intellectual importance, taught by faculty in their areas of expertise and illuminating many paths of discovery at ASU. "Y" grade. Seminar.

M MAE 212 Engineering Mechanics. (4)
fall, spring, selected summers
Force systems, resultants, moments and equilibrium. Kinematics and kinetics of particles, systems of particles and rigid bodies. Energy and momentum principles. Lecture, recitation. Prerequisites: PHY 121, 122. Pre- or corequisite: preferably MAT 275 (or 274).

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 93.

M MAE 213 Solid Mechanics. (3)
fall, spring, selected summers
Equilibrium, strain-displacement relations, and stress-strain-temperature relations. Applications to force transmission and deformations in axial, torsional, and bending of bars. Combined loadings. Lecture, recitation. Prerequisite: preferably MAE 212 or CEE 211.

M MAE 214 Computer-Aided Engineering I. (1)
fall, spring, selected summers
Introduces geometry and construction techniques in CAD, technical drawing conventions, generating drawings from CAD models. Lab. Fee. Pre- or corequisite: preferably MAE 213 or CEE 213.

M MAE 240 Thermofluids I. (4)
fall, spring, selected summers
Introductory concepts of thermodynamics, fluid mechanics, and heat transfer. Prerequisites: CHM 114; preferably MAE 212 (or CEE 211); PHY 131, 132.

M MAE 313 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 318, 360.

M MAE 318 Sensors and Controls. (5)
fall and spring
Introduces measurement systems, feedback control modelling and dynamics of physical systems, computer simulations and real-time experiments. Integrated lecture/lab. Fee. Prerequisites: EEE 202; MAE 212.

M MAE 322 Mechanics of Materials. (4)
fall and spring
Three-dimensional stress analysis, failure theories, energy methods, finite elements, torsion of noncircular members, unsymmetrical bending, beam column, fatigue and fracture. Fee. Lecture, lab. Prerequisite: MAE 213; MAT 343. Pre- or corequisite: MAE 384.

M MAE 323 Computer-Aided Engineering II. (1)
fall, spring, selected summers
Introduces finite-element analysis, pre- and postprocessing, solving problems with FEA. Lab. Fee. Prerequisite: MAE 214. Pre- or corequisite: MAE 322.

M MAE 340 Thermofluids II. (3)
fall and spring
Intermediate concepts of thermodynamics, fluid mechanics, and heat transfer. Prerequisite: MAE 240.

M 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: MAE 212.

M MAE 342 Principles of Design. (3)
fall and spring
The design process; conceptual and embodiment design of mechanical elements; form synthesis; material selection, failure modes, manufacturability tolerances, common mechanisms and machine elements. Fee. Lecture, lab (project). Prerequisites: MAE 318, 322; MSE 250.

M MAE 343 Computer-Aided Engineering III. (1)
fall, spring, selected summers
Solution to fluid mechanics and heat transfer problems using Finite Element Analysis (FEA). Lab. Fee. Prerequisites: MAE 214, 240.

M MAE 344 Fundamentals of Aerospace Design. (3)
spring
Design theory and design tools applied to aerospace engineering. Engineering drawings, aircraft performance, RFP's, Federal Aviation Regulations and military specifications, aircraft sizing, rapid prototyping. Fee. Lab, projects. Prerequisites: MAE 322, 360, 384.

M 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 MAE 351 or IEE 360. Fee. Prerequisite: MSE 250.

M MAE 360 Aerodynamics. (4)
fall
Airfoils and wings, ideal flow, panel methods, boundary layers, finite-difference solutions, wind-tunnel testing. 3 hours lecture, 1 hour lab. Fee. Prerequisites: ENG 102; MAE 240. Pre- or corequisite: MAE 384.

M MAE 362 High-Speed Aerodynamics. (4)
spring
Compressible flow at subsonic and supersonic speeds; ducts, nozzles, and diffusers; normal and oblique shocks, transonic flow, numerical solutions; experimental applications. 3 hours lecture, 1 hour lab. Fee. Prerequisites: preferably MAE 360 (or 240 and instructor approval), 384.

M MAE 372 Fluid Mechanics. (3)
once a year
Applies basic principles of fluid mechanics to problems in viscous and compressible flow. Prerequisites: MAE 340 (or 360), 384.

M MAE 382 Thermodynamics. (3)
once a year
Applied thermodynamics; gas mixtures, psychrometrics, property relationships, power and refrigeration cycles, and reactive systems. Prerequisite: MAE 240.

M MAE 384 Numerical Methods for Engineers. (3)
fall and spring
Numerical methods and computational tools for selected problems in engineering. Cross listed as CEE 384. Credit is allowed for only MAE 384 or CEE 384. Prerequisites: preferably MAT 275 or 274, preferably 343 or 242 or 342. Pre- or corequisite: MAT 272 or 294 ST: Calculus for Engineers III.

M MAE 394 Special Topics. (1–4)
selected semesters

M MAE 400 Engineering Profession. (3)
fall and spring
Impact of mechanical and aerospace engineering in a global and societal context; effects of and on globalization, environment, sustainability, economy, politics; engineering ethics and business practices. Prerequisites: MAE 362 (or 491); senior standing in Aerospace or Mechanical Engineering.

M 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: MAE 213 (or CEE 213), 384 (or CEE 384).

M 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. Fee. 3 hours lecture, 3 hours lab. Prerequisites: MAE 342 (or 344), 384.

M MAE 415 Vibration Analysis. (3)
spring
Free and forced response of single and multiple degree of freedom systems, continuous systems; applications in mechanical and aerospace systems numerical methods. Fee. Prerequisites: MAE 213, 384.

M 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 318.

M 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 322.

M MAE 433 Air Conditioning and Refrigeration. (3)
once a year
Air conditioning processes; environmental control; heating and cooling loads; psychrometry; refrigeration cycles. Prerequisite: MAE 340 or instructor approval.

M MAE 434 Internal Combustion Engines. (3)
once a year
Performance characteristics, combustion, carburetion and fuel-injection, and the cooling and control of internal combustion engines. Computer modeling. Fee. Lab. Prerequisite: MAE 340 or instructor approval.

M MAE 435 Turbomachinery. (3)
once a year
Design and performance of turbomachines, including steam, gas and hydraulic turbines, centrifugal pumps, compressors, fans, and blowers. Prerequisite: MAE 340 or 360.

M 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 340 or instructor approval.

M MAE 442 Mechanical Systems Design. (4)
spring
Applies design principles and techniques to the synthesis, modeling, and optimization of mechanical, electromechanical, and hydraulic systems. Fee. Lecture, lab. Prerequisites: MAE 318, 342 (or 344).

M 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: MAE 340.

M 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 318.

M 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

M 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: MSE 211 (or CEE 213 or MAE 213), 250.

M 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 318.

M 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: MAE 362, 384.

M 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 340 or 362.

M 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. Prerequisite: MAE 360 or instructor approval.

M 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. Prerequisite: MAE 344. Pre- or corequisite: MAE 463.
General Studies: L

M MAE 469 Projects in Astronautics or Aeronautics. (3)
fall and spring
Various multidisciplinary team projects available each semester. Projects include design of high-speed rotocraft autonomous vehicles, liquid-fueled rockets, microaerial vehicles, satellites. Fee. Prerequisite: instructor approval.

M MAE 471 Computational Fluid Dynamics. (3)
once a year
Numerical solutions for selected problems in fluid mechanics. Fee. Prerequisites: MAE 340 (or 360), 384.

M MAE 488 Mechanical Engineering Design I. (3)
fall
Conceptual and embodiment design; modeling; rapid prototyping. Team project. MAE 488 and 489 must be taken in consecutive semesters. Lecture, discussion. Fee.Prerequisites: MAE 340, 342.

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

M 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. Fee. 6 hours lab. Prerequisites: MAE 318, 340.
General Studies: L

M MAE 492 Honors Directed Study. (1–6)
selected semesters

M MAE 493 Honors Thesis. (1–6)
selected semesters

M 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.

M 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/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.

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 93.

Programs in Engineering Special Studies

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.

ENGINEERING SPECIAL STUDIES—BSE

At the current time there is only one concentration available for this program—premedical engineering.

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.

ADMISSION REQUIREMENTS

Preprofessional Program. All students admitted to the Engineering Special Studies program with a concentration in premedical engineering will be admitted to the preprofessional program. During the time students are in the preprofessional program, they will follow the sequence of first- and second-year courses shown in the Typical Four-Year Sequence for the concentration. Promotion from the preprofessional program to the professional program is not automatic and a separate application procedure is required.

Promotion is based on performance in a collection of skill-set courses all of which are included in the typical first three semesters of the program. The skill-set courses are:

Skill-Set Courses

BIO	188	General Biology II[1] *SQ*	4
BME	100	Introduction to Bioengineering *CS*	3
BME	294	ST: Conservation Principles in Bioengineering	3
CHM	116	General Chemistry II *SQ*[2]	4
MAT	294	ST: Calculus for Engineers I	3
MAT	294	ST: Calculus for Engineers II	3
PHY	121	University Physics I: Mechanics *SQ*[3]	3
PHY	122	University Physics Laboratory I *SQ*[3]	1
PHY	131	University Physics II: Electricity and Magnetism *SQ*[4]	3
PHY	132	University Physics Laboratory II *SQ*[4]	1
Skill-set course total			28

[1] Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.

[2] To fulfill medical school admission requirements, premedical students generally should choose CHM 116. Note that CHM 113 is required by many medical schools in addition to CHM 116. CHM 113 cannot be used as a technical elective.

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

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

Professional Program. Admission to the professional program is competitive. All students seeking admission to the professional program must follow the application procedure described in the Harrington Department of Bioengineering Web site. Admission is granted to those applicants who have demonstrated high promise for professional success. Transfer students who have completed the equivalent required lower-division skill-set courses may also apply to the professional program. While only students who have been admitted to the bioengineering program are eligible to apply to the professional program, prior attendance at ASU is not required. Completion of the specified preprofessional course work does not guarantee admission to the professional program.

DEGREE REQUIREMENTS

A minimum of 120 semester hours is necessary for the BSE degree in Engineering Special Studies with a concentration in Premedical Engineering. A minimum of 45 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 89.

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[1]

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)

First-year composition subtotal 6

General Studies/Program Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

HU/SB and awareness area courses[2] 15

Total 15

Literacy and Critical Inquiry

Six hours of literacy and critical inquiry credit is satisfied by courses in the major.

Natural Sciences

BIO 188 General Biology II *SQ*[1, 2] 4
CHM 113 General Chemistry I *SQ* 4
CHM 116 General Chemistry II *SQ* 4
CHM 233 General Organic Chemistry I[3] 3
CHM 237 General Organic Chemistry Laboratory I[3] 1
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

Natural sciences subtotal 24

Mathematical Studies

CSE 100 Principles of Programming with C++ *CS* 3
MAT 274 Elementary Differential Equations *MA* 3
MAT 294 ST: Calculus for Engineers I 3
MAT 294 ST: Calculus for Engineers II 3
MAT 343 Applied Linear Algebra 3

Mathematical studies subtotal 15

General Studies/program requirements total 54

Lower-Division Engineering Courses

BME 100 Introduction to Bioengineering *CS* 3
BME 235 Physiology for Engineers 4
BME 294 ST: Conservation Principles in Bioengineering 3
EEE 202 Circuits I 4
IEE 280 Probability and Statistics for Engineering Problem Solving *CS* 3
MAE 212 Engineering Mechanics 4

Lower-division subtotal 21

Upper-Division Courses in Major

BME 300 Bioengineering Product Design 3
BME 318 Biomaterials 4
BME 331 Bioengineering Transport Phenomena 3
BME 350 Signals and Systems for Bioengineers 3
BME 370 Microcomputer Applications in Bioengineering 3
BME 413 Biomedical Instrumentation *L*[6] 3
BME 417 Biomedical Engineering Capstone Design I 4
BME 423 Biomedical Instrumentation Laboratory *L*[6] 1
BME 434 Applications of Bioengineering Transport Phenomena 3
or BME 416 Biomechanics (3)
or BME 419 Biocontrol Systems (3)
BME 490 Biomedical Engineering Capstone Design II 4
CHM 234 General Organic Chemistry II 3
CHM 238 General Organic Chemistry Laboratory II 1
CHM 341 Elementary Physical Chemistry 3
Technical electives[7] 1

Upper-division courses in major subtotal 39

Program total 120

---

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

2 Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.

3 If CHM 233/237 is taken to satisfy the natural science requirement, these courses are not eligible to be applied as technical electives.

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

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

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

7 Acceptable courses require advisor approval.

Premedical Engineering
Program of Study
Typical Four-Year Sequence

First Year

First Semester

BME 100 Introduction to Bioengineering *CS* 3
CHM 113 General Chemistry I *SQ* 4
ENG 101 First-Year Composition 3
MAT 294 ST: Calculus for Engineers I 3

Total 13

Second Semester

BIO 188 General Biology II *SQ*[1] 4
CHM 116 General Chemistry II *SQ* 4
ENG 102 First-Year Composition 3
MAT 294 ST: Calculus for Engineers II 3
PHY 121 University Physics I: Mechanics *SQ*[2] 3
PHY 122 University Physics Laboratory I *SQ*[2] 1

Total 18

Second Year

First Semester

BME 294 ST: Conservation Principles in Bioengineering 3
CHM 233 General Organic Chemistry I[3] 3
CHM 237 General Organic Chemistry Laboratory I[3] 1
CSE 100 Principles of Programming with C++ *CS* 3
PHY 131 University Physics II: Electricity and Magnetism *SQ*[4] 3
PHY 132 University Physics II Laboratory *SQ*[4] 1

Total 14

Second Semester

BME 235 Physiology for Engineers 4
EEE 202 Circuits I 4
IEE 280 Probability and Statistics for Engineering Problem Solving 3
MAT 275 Modern Differential Equations *MA* 3
HU/SB and awareness area course[5] 3

Total 17

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 93.

Third Year

First Semester

BME 318 Biomaterials 4
CHM 341 Elementary Physical Chemistry 3
MAE 212 Engineering Mechanics 4
MAT 343 Applied Linear Algebra 3
HU/SB and awareness area course[5] 3
Total 17

Second Semester

BME 300 Bioengineering Product Design 3
BME 331 Bioengineering Transport Phenomena 3
BME 350 Signals and Systems for Bioengineers 3
BME 370 Microcomputer Applications in Bioengineering 3
HU/SB and awareness area course[5] 3
Total 15

Fourth Year

First Semester

BME 413 Biomedical Instrumentation *L*[6] 3
BME 417 Biomedical Engineering Capstone Design I 4
BME 423 Biomedical Instrumentation Laboratory *L*[6] 1
BME 434 Applications of Bioengineering Transport Phenomena 3
or BME 416 Biomechanics (3)
or BME 419 Biocontrol Systems (3)
CHM 234 General Organic Chemistry II 3
CHM 238 General Organic Chemistry Laboratory II 1
Total 15

Second Semester

BME 490 Biomedical Engineering Capstone Design II 4
HU/SB electives[5] 6
Technical elective 1
Total 11

Total degree requirements 120

---

1 Note that BIO 187 is required by many medical schools in addition to BIO 188. BIO 187 cannot be used as a technical elective.
2 Both PHY 121 and PHY 122 must be taken to secure SQ credit.
3 If CHM 233/237 is taken to satisfy the natural science requirement, these courses are not eligible to be applied as technical electives.
4 Both PHY 131 and PHY 132 must be taken to secure SQ credit.
5 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.
6 Both BME 413 and BME 423 must be taken to secure L credit.

ASU Research Park

Tim Trumble photo