

# College of Engineering and Applied Sciences

**Peter E. Crouch, Ph.D.**  
*Dean*

## PURPOSE

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

## ORGANIZATION

The College of Engineering and Applied Sciences is composed of the following academic and service units:

### **School of Agribusiness and Resource Management**

The School of Agribusiness and Resource Management is located at ASU East. See pages 420–425.

### **Del E. Webb School of Construction**

#### **School of Engineering**

Department of Chemical, Bio and Materials Engineering  
Department of Civil and Environmental Engineering  
Department of Computer Science and Engineering  
Department of Electrical Engineering  
Department of Industrial and Management Systems Engineering  
Department of Mechanical and Aerospace Engineering

### **School of Technology**

The School of Technology is located at ASU East. See pages 425–440.

Department of Aeronautical Technology  
Department of Electronics and Computer Technology  
Department of Manufacturing and Industrial Technology

The Office of the Dean administers programs in engineering special studies.

**Research Centers.** The college is committed to the development of research programs of national prominence and to the concept that research

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

Aerospace Research Center  
Center for Advanced Transportation Systems Research  
Center for Agribusiness Policy Studies (The Center for Agribusiness Policy Studies is located at ASU East. See page 421.)  
Center for Energy Systems Research  
Center for Innovation in Engineering Education  
Center for Research in Engineering and Applied Sciences  
Center for Solid State Electronics Research  
Computer-Integrated Manufacturing Systems Research Center  
Systems Science and Engineering Research Center  
Telecommunications Research Center

### **Center for Professional Development.**

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

Programs may be conducted on campus, at various off-campus locations, or at company sites upon request. For more information, contact the Center for Professional Development, located in ECG 148, at 602/965–1740.

## ADMISSION

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

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

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

**Professional Status.** For admission to *professional status*, Arizona residents must meet one of the requirements as listed in the table, "Professional Status Requirements for Residents."

For admission to professional status, a nonresident must meet one of the requirements as listed in the table, "Pro-

fessional Status Requirements for Non-residents." In addition, an international student must satisfy minimum TOEFL score requirements as shown in the table.

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

**Preprofessional Status.** A student not admissible to professional status within the college but otherwise regularly admissible to ASU as stated on page 47, "Undergraduate Admission," may be admitted as a *preprofessional* student to any one of the departments or schools of the college. International students whose TOEFL scores do not meet the required minimum shown in the tables below may also be admitted to preprofessional status. A student admitted into this classification follows the freshman-sophomore sequence of courses as required by the chosen major. Courses are selected with the assistance of an academic advisor. After completing a minimum of 30 semester hours of required or approved elective courses

*with a cumulative GPA equivalent to that required of transfer students and corresponding to the chosen major*, students may apply for admission to professional status. *International students must also submit a TOEFL score equivalent to that required for admission to professional status* (refer to the table below). Preprofessional students are not permitted to register for 300- and 400-level courses in the College of Engineering and Applied Sciences until their status is changed to the professional classification.

**Readmission.** Students applying for readmission to professional status for any program in this college must have a cumulative GPA for all college course work equal to that of the transfer admission requirements shown below. A student who does not meet these requirements may request admission to preprofessional status, subject to the restrictions shown above.

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

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

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

### Professional Status Requirements for Residents

School	High School Rank	Minimum Scores	
		ACT	SAT
Agribusiness and Resource Management	Upper 50%	22	1040
Construction	Upper 25%	23	1140
Engineering	Upper 25%	23	1140
Technology	Upper 50%	22	1040

### Professional Status Requirements for Nonresidents

School	High School Rank	Minimum Scores		
		ACT	SAT	TOEFL*
Agribusiness and Resource Management	Upper 25%	24	1110	500
Construction	Upper 25%	24	1140	550
Engineering	Upper 25%	24	1140	550
Technology	Upper 25%	24	1110	500

\* For international students (see page 52).

**Professional Status Requirements for Transfer Students**

School	Transfer GPA <sup>1</sup>		TOEFL <sup>2</sup>
	Resident	Nonresident	
Agribusiness and Resource Management	2.00	2.50	500
Construction	2.50	2.50	550
Engineering	2.50	2.50	550
Technology	2.25	2.50	500

<sup>1</sup> The cumulative GPA is calculated using all credits from ASU and from other colleges and universities.

<sup>2</sup> For international students (see page 52).

Credit is granted for transferred courses deemed equivalent to corresponding courses in the selected program of study, subject to grade and senior residence requirements. No grades lower than “C” are accepted as transfer credit to meet the graduation requirements of this college. Credits transferred from a community college or two-year institution are applied only as lower-division credits. Prospective Arizona community college transfer students should consult their advisors and refer to the annual *Arizona Higher Education Course Equivalency Guide* for a listing of the acceptable courses transferable to the various college degree programs.

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

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

A student in the college is eligible to apply upon completion of 45 or more

hours of classes in the selected major. Certain positions may require completion of specific courses of study. Transfer students are required to complete at least one semester at ASU before beginning work. All student applicants must have a GPA of at least 2.50 and the approval of an advisor.

To maintain continuous student status in the university, each co-op student must be enrolled in ASE 399 Cooperative Work Experience for one semester hour during each work session. Such credit cannot be applied toward degree requirements. For more information, contact the director of Student Academic Services at 602/965-5150 (ECG 102) or the Career Services office at 602/965-2350 (SSV C359).

**ADVISING**

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

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

Students enrolled in this college may register for a maximum of 19 semester hours each semester. Any student wanting to register for more than the maximum must petition the CEAS

Standards Committee and must have an approval on file before registering for the overload.

**Minority Engineering Program.** The staff of the Minority Engineering Program (MEP) is available to assist the academic and professional development of prospective, newly admitted, and continuing students through a variety of support services. In addition, advice on financial aid, scholarships, and employment is provided. The MEP office is located in room ECG 307.

**Women in Applied Sciences and Engineering Program.** The Women in Applied Sciences and Engineering (WISE) Program hosts seminars and workshops, and provides outreach programs to high-school and community-college students. WISE offers a professional development course, ASE 194, to acquaint students with a variety of technical careers. The WISE Center, located in room ECG 214, is open for study groups, tutoring, and informal discussions.

**DEGREES**

**Majors.** Programs leading to the B.S. and B.S.E. degrees are offered by the College of Engineering and Applied Sciences, with majors in the subjects shown in the table, “College of Engineering and Applied Sciences Degrees, Majors, and Concentrations,” pages 266-268. Each major is administered by the academic unit indicated.

**Integrated B.S.E.–M.S. Program.** To provide greater program flexibility, qualified students of the School of Engineering may undertake a program with an integrated fourth- and fifth-year sequence of study in one of several fields of specialization in engineering. This program provides an opportunity to meet the increasing demands of the profession for graduates who can begin their engineering careers at an advanced level.

Students admitted to this program are assigned a faculty committee that supervises a program of study in which there is a progression in the course work and in which earlier work is given application in the later engineering courses for both the bachelor’s and

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71-94. For graduation requirements, see pages 66-70. Omnibus courses are offered that are not listed in the catalog; see pages 44-45.

**College of Engineering and Applied Sciences  
Degrees, Majors, and Concentrations**

Major	Degree	Administered by
<b>Baccalaureate Degrees</b>		
<b>School of Agribusiness and Resource Management</b> (The School of Agribusiness and Resource Management is located at ASU East. See pages 420–425.)		
Agribusiness Concentrations: agribusiness, computer analysis, pre-veterinary medicine	B.S.	School of Agribusiness and Resource Management
<b>Del E. Webb School of Construction</b>		
Construction Options: general building construction, heavy construction, military construction, residential construction, specialty construction	B.S.	Del E. Webb School of Construction
<b>School of Engineering</b>		
Aerospace Engineering Emphases: aerodynamics, aerospace materials, aerospace structures, computer methods, design, mechanical, propulsion, system dynamics and control	B.S.E.	Department of Mechanical and Aerospace Engineering
Bioengineering Emphases: biochemical engineering, bioelectrical engineering, biomaterials engineering, biomechanical engineering, biomedical imaging engineering, biosystems engineering, molecular and cellular, bioengineering, pre-medical engineering	B.S.E.	Department of Chemical, Bio and Materials Engineering
Chemical Engineering Emphases: biochemical, biomedical, environmental, materials, pre-medical, process engineering, semiconductor processing	B.S.E.	Department of Chemical, Bio and Materials Engineering
Civil Engineering Option: environmental engineering	B.S.E.	Department of Civil and Environmental Engineering
Computer Science	B.S.	Department of Computer Science and Engineering
Computer Systems Engineering	B.S.E.	Department of Computer Science and Engineering
Electrical Engineering	B.S.E.	Department of Electrical Engineering
Engineering Interdisciplinary Studies <sup>2</sup>	B.S.	School of Engineering
Engineering Special Studies Options: manufacturing engineering, pre-medical engineering	B.S.E.	School of Engineering
Industrial Engineering	B.S.E.	Department of Industrial and Management Systems Engineering
Materials Science and Engineering Emphases: biomaterials, ceramic materials, energy systems, integrated circuit materials, manufacturing and materials processing, mechanical metallurgy, metallic materials systems, polymers and composites	B.S.E.	Department of Chemical, Bio and Materials Engineering

<sup>1</sup> This program is administered by the Graduate College. See the “Graduate College” section of this catalog.

<sup>2</sup> Applications for this program are not being accepted at this time.

Major	Degree	Administered by
Mechanical Engineering Emphases: aerospace; biomechanical; computer methods; control and dynamic systems; design; energy systems; engineering mechanics; manufacturing; stress analysis, failure prevention, and materials; thermosciences	B.S.E.	Department of Mechanical and Aerospace Engineering
<b>School of Technology</b> (The School of Technology is located at ASU East. See pages 425–440.)		
Aeronautical Engineering Technology Option: aeronautical technology	B.S.	Department of Aeronautical Technology
Aeronautical Management Technology Options: <i>ab initio</i> airline pilot flight management, airway science aircraft systems management, airway science management	B.S.	Department of Aeronautical Technology
Electronics Engineering Technology Options: computer systems, electronic systems, microelectronics, telecommunications	B.S.	Department of Electronics and Computer Technology
Industrial Technology Emphases: graphic communications, industrial management, interactive computer graphics	B.S.	Department of Manufacturing and Industrial Technology
Manufacturing Engineering Technology Emphases: computer-integrated manufacturing engineering technology, manufacturing engineering technology, mechanical engineering technology, robotic and automation engineering technology, welding engineering technology	B.S.	Department of Manufacturing and Industrial Technology
<b>Graduate Degrees</b>		
<b>School of Agribusiness and Resource Management</b> (The School of Agribusiness and Resource Management is located at ASU East. See pages 420–425.)		
Agribusiness Concentrations: agribusiness management and marketing, food quality assurance	M.S.	School of Agribusiness and Resource Management
<b>Del E. Webb School of Construction</b>		
Construction Concentrations: construction science, facilities, management	M.S.	Del E. Webb School of Construction
<b>School of Engineering</b>		
Aerospace Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Bioengineering	M.S., Ph.D.	Department of Chemical, Bio and Materials Engineering
Chemical Engineering Concentrations: biomedical and clinical engineering, chemical process engineering, chemical reactor engineering, energy and materials conversion, environmental control, solid state processing, transport phenomena	M.S., M.S.E., Ph.D.	Department of Chemical, Bio and Materials Engineering

<sup>1</sup> This program is administered by the Graduate College. See the “Graduate College” section of this catalog.

<sup>2</sup> Applications for this program are not being accepted at this time.

Major	Degree	Administered by
Civil Engineering Concentrations: environmental/sanitary, geotechnical/soil mechanics, structures, transportation, water resources/hydraulics	M.S., M.S.E., Ph.D.	Department of Civil and Environmental Engineering
Computer Science	M.C.S., M.S., Ph.D.	Department of Computer Science and Engineering
Electrical Engineering	M.S., M.S.E., Ph.D.	Department of Electrical Engineering
Engineering Science	M.S., M.S.E., Ph.D.	School of Engineering
Industrial Engineering Concentrations: computer-aided processes, computer-integrated manufacturing, human factors, information systems, operations research, organization control, quality control/reliability	M.S., M.S.E., Ph.D.	Department of Industrial and Management Systems Engineering
Mechanical Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Science and Engineering of Materials	Ph.D. <sup>1</sup>	Committee on the Science and Engineering of Materials
<b>School of Technology</b> (The School of Technology is located at ASU East. See pages 425–440.)		
Technology Concentrations: aeronautical engineering technology, aeronautical management technology electronics engineering technology  graphic communications technology, industrial management and supervision, manufacturing engineering technology, mechanical engineering technology, welding engineering technology	M.Tech.	Department of Aeronautical Technology  Department of Electronics and Computer Technology Department of Manufacturing and Industrial Technology

<sup>1</sup> This program is administered by the Graduate College. See the “Graduate College” section of this catalog.

<sup>2</sup> Applications for this program are not being accepted at this time.

master’s degrees. Entry into the integrated program requires an application submitted to the dean through the faculty advisor and the department chair. Applications are reviewed by a school committee that recommends the appropriate action to the dean. The application may be submitted in the fifth semester.

### Graduate Degrees

Deficiencies for admission to the graduate degree programs are specified at the time of admission. The verbal, quantitative, and analytical components of the Graduate Record Examination (GRE) are recommended but are not required unless specified by the respective academic unit. TOEFL scores must be submitted by international applicants before admission is considered. Applicants with scores below 550 are regu-

larly admitted without requiring further language study. Applicants with scores below 550 are regularly admitted but must complete study in ASU’s American Language and Culture Program (ALCP) before enrolling in course work in the academic program.

### Master of Computer Science Degree (M.C.S.)

The M.C.S. program provides a professionally oriented, graduate-level education in computer science and engineering. All of the Graduate College entrance requirements and departmental academic performance and preparation requirements must be satisfied for admission. The applicant must have a baccalaureate degree in computer science, computer engineering, or a closely related field. The M.C.S. program requires a minimum of 30 semester hours of approved graduate-level

course work. At the end of the program of study, the student must pass a final comprehensive examination over the graduate course work taken for the degree and over the appropriate undergraduate prerequisites. Details of the content and format of the examination are available from the department.

### Master of Science Degree (M.S.)

**Agribusiness.** This program provides competent students with opportunities to complete advanced studies with emphasis on research. Areas of study in Agribusiness may be management, marketing, finance, international agriculture, and the food industry. Admission requires completion of 18 semester hours in agribusiness or closely related course work. Scores from the GRE or Miller Analogies Test (MAT) are required. A minimum of 30 semester

hours of approved graduate course work is required, including a thesis. An oral examination in defense of the thesis is required. This program is located at ASU East. For more information, see pages 420–424.

**Computer Science.** This graduate program provides opportunities for qualified students holding a baccalaureate degree in computer science or related fields to complete advanced studies with emphasis on research. A minimum of 30 semester hours of approved course work is required, including a thesis. An oral examination in defense of the thesis is required.

**Construction.** This graduate program provides opportunities for qualified students holding a baccalaureate degree in construction, engineering, architecture, or a related discipline to complete advanced studies with an emphasis on management and research. The construction science concentration allows candidates whose primary interest is field engineering or supervision of heavy and industrial construction projects to pursue a more technically oriented course of study. The construction management concentration allows candidates pursuing upper-level management positions in various sectors of the construction industry to improve their competency in project, program, and company management areas. The facilities management concentration supports the needs of the student whose aim is to pursue careers in the maintenance, operation, renovation, or decommissioning of existing facilities.

**Engineering Science.** These research-oriented graduate-degree programs provide opportunities to highly competent students to major in aerospace, chemical, civil, electrical, industrial, or mechanical engineering, bioengineering, or engineering science. Options in aerospace engineering, biotechnology, engineering mechanics, engineering science, and materials science and engineering are available under the Engineering Science major. M.S.E. and Ph.D. degree programs are also available in these options.

The M.S. degree program (including all options) is administered through the office of the college associate dean for

academic affairs. Admission normally requires an appropriate undergraduate engineering degree and satisfaction of all Graduate College admission requirements and special department requirements. A minimum of 30 semester hours of approved graduate course work is required, which must include a thesis and an oral examination at the completion of the program. Students writing a thesis must enroll in a combination of both 592 Research and 599 Thesis, totaling six semester hours.

#### **Master of Science in Engineering Degree (M.S.E.)**

These professionally oriented graduate degree programs are intended as a preparation for a career in professional practice. Two options are available within the Master of Science in Engineering degree programs. Option 1 (thesis option) is designed primarily for full-time students. A thesis (engineering report or research paper) is required of students following this option. Option 2 is designed for full-time students not intending to write a thesis and for students who hold full-time jobs and must attend university classes on a part-time basis. Both options require a minimum of 30 semester hours of approved graduate-level course work. For entry, the student must satisfy all Graduate College admission requirements and special department requirements and must have a baccalaureate degree in engineering or another closely related degree program.

#### **Master of Technology Degree (M.Tech.)**

This degree program is designed for flexibility, permitting the student to select a combination of courses in technology and supporting areas to meet individual career goals. Selected areas of concentration are designed to provide graduates with technical and professional skills for use in preparation for and advancement in leadership positions found in industry and education. The Master of Technology is offered by the Departments of Aeronautical Technology, Electronics and Computer Technology, and Manufacturing and Industrial Technology. Admission requires an appropriate baccalaureate degree with a minimum of 30 semester

hours in technology or equivalent. A minimum of 32 semester hours of approved course work is required, including a practicum or applied project. An oral examination in defense of the practicum or applied project is required. This program is located at ASU East. For more information, see pages 425–440.

#### **Doctor of Philosophy Degree**

The Ph.D. degree is awarded in engineering or Computer Science upon the satisfactory completion of an approved program of graduate study, research, and dissertation. For specific reference to this degree, see the “Graduate College” section of this catalog or the *Graduate Catalog*.

#### **DEGREE REQUIREMENTS**

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

#### **GRADUATION REQUIREMENTS**

In addition to department and school requirements, students must meet all university graduation requirements (see pages 66–70) as well as satisfy all the following prerequisites. A well-planned program of study enables students to meet all requirements in a timely fashion. Students are encouraged to consult with an academic advisor in planning a program to ensure that they comply with all necessary requirements.

**General Studies Requirement.** All students enrolled in a baccalaureate degree program must satisfy a university requirement of a minimum of 35 hours of approved course work in General Studies, as described on pages 71–74. General Studies courses are listed on pages 74–94 in the *General Catalog* following the section on *General Studies*, in the course descriptions, in the *Schedule of Classes*, and in the *Summer Sessions Bulletin*.

**First-Year Composition Requirement.** As a minimum, completion of both ENG 101 and 102 or ENG 105 with a grade of “C” or better is required

for graduation from ASU in any baccalaureate program (see page 67); but 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. See “First-Year Composition Requirement,” page 66.

**Pass/Fail Grades.** Students enrolled in the College of Engineering and Applied Sciences do not receive degree credit for pass/fail courses taken at this institution. In addition, no course in this college is offered for pass/fail credit. Students requesting credit for pass/fail courses taken at another institution must file a Petition for Adjustment to Curriculum Requirements. Each request is judged on its particular merits.

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

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

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

## ACADEMIC STANDARDS

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

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

Students not meeting department standards are placed on probation at the department’s discretion.

Students on probation are subject to disqualification if (1) they do not attain a semester GPA of 2.25 (2.50 for pre-professional students in the School of Engineering) and their cumulative GPA is below 2.00 at the end of the probationary semester or (2) they are placed on probation for two consecutive semesters.

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

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

**Disqualification.** During a semester on academic probation, a student who fails to meet the retention standards specified above is disqualified. Students may request a review of their disqualification status by contacting the associate director of Student Academic Services in ECG 115. Any disqualified student who is accepted by another college at ASU may not register for courses in this college unless the courses are required for the new major. Disqualified students who do register for courses in this college may be withdrawn from these courses any time during that semester. Furthermore, students at the university who have been disqualified academically by this college are not eligible to enroll in summer session courses in this college until the disqualification period has expired and they have been reinstated.

**Reinstatement.** The College of Engineering and Applied Sciences does not accept an application for reinstatement until the disqualified student has remained out of this college for at least a 12-month period. Merely having remained in a disqualified status for this

period of time does not, in itself, constitute a basis for reinstatement. Proof of ability to do satisfactory college work in the chosen discipline is required, for example, completing pertinent courses in the discipline at a community college with better than average grades.

## STUDENT RESPONSIBILITIES

**Course Prerequisites.** It is expected that students consult the *Schedule of Classes* and the catalog with regard to 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 effected by the instructor, the chair of the department offering the course, the director of Student Academic Services, or the dean of the college. In such cases, there is no monetary reimbursement to the student. However, such withdrawal is considered to be unrestricted as described on page 61 and does not count against the number of restricted withdrawals allowed.

## SPECIAL PROGRAMS

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

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

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

1. Alpha Pi Mu—Industrial Engineering Honor Society;
2. Alpha Zeta—Agriculture Honor Society;

3. Chi Epsilon—Civil Engineering Honor Society;
4. Eta Kappa Nu—Electrical Engineering Honor Society;
5. Pi Tau Sigma—Mechanical Engineering Honor Society;
6. Sigma Gamma Tau—Aerospace Engineering Honor Society;
7. Sigma Lambda Chi—Construction Honor Society;
8. Tau Alpha Pi—National Honor Society, Engineering Technologies;
9. Tau Beta Pi—National Engineering Honor Society; and
10. Upsilon Pi Epsilon—National Computer Science Honor Society.

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

**University Honors College.** The College of Engineering and Applied Sciences participates in the programs of the University Honors College, which provides enhanced educational experiences to superior undergraduate students. Participating students can major in any academic program. A description of the requirements and the opportunities offered by the University Honors College can be found on pages 99–101 of this catalog.

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

**ASU 3+2 Programs.** Students desiring to earn a baccalaureate degree from Grand Canyon University (Phoenix, Arizona) in Mathematics, Chemistry, Construction, or Physics or from Southwestern University (Georgetown, Texas) in Physical Science and a baccalaureate degree in one of the engineering majors or the Construction major from ASU can take advantage of a 3+2 program approved by these institutions.

Such students complete the first three years of study at their respective college or university and the last two years of study at ASU. At the end of the fourth or fifth year, assuming all degree requirements have been met, the baccalaureate degree is awarded by the student's respective college or university and the appropriate engineering or construction baccalaureate degree is awarded by ASU.

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

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

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

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

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

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

The Del E. Webb School of Construction also has 2+2 agreements with several selected out-of-state colleges and universities. For a listing and additional information, call 602/965-3615, or write

DIRECTOR, DEL E. WEBB SCHOOL  
OF CONSTRUCTION  
ARIZONA STATE UNIVERSITY  
PO BOX 870204  
TEMPE AZ 85287-0204

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

A military construction option is available in the Del E. Webb School of Construction. See page 274 for details.

## GENERAL INFORMATION

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

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

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

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

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## Del E. Webb School of Construction

William W. Badger  
*Director*  
 (COB 268) 602/965-3615

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### PROFESSORS

BADGER, MULLIGAN

### ASSOCIATE PROFESSORS

MAYO, WEBER

### ASSISTANT PROFESSORS

CHASEY, HAMILTON,  
 KASHIWAGI, WALSH, WIEZEL

### VISITING EMINENT SCHOLAR

SCHEXNAYDER

### PROFESSORS EMERITI

BURTON, HASTINGS, PETERMAN,  
 WARD, WOODING

### PURPOSE

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

### DEGREES

#### Bachelor of Science (B.S.) Degree.

The Del E. Webb School of Construction offers the Bachelor of Science degree with a major in Construction. Five options are available: general building, heavy construction, residential construction, military construction, and specialty construction.

Each option is arranged to accent requisite technical skills and to develop management, leadership, and competitive qualities in the student. Prescribed are a combination of General Studies, technical courses basic to engineering and construction, and a broad range of applied management subjects fundamental to the business of construction contracting. The military construction option complements the heavy construction option but permits the use of 18 semester hours of ROTC credits for appropriate technical electives and management courses.

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

**Professional Accreditation and Affiliations.** The Del E. Webb School of Construction is a member of the Associated Schools of Construction, an organization dedicated to the development and advancement of construction education. The construction program is accredited by the American Council for Construction Education (ACCE).

### SPECIAL PROGRAMS

**ASU 2+2 Program.** The Del E. Webb School of Construction maintains a cooperative agreement with most community colleges within Arizona and also with selected out-of-state colleges and universities to structure courses that are directly transferable into the construction program at ASU.

**ASU 3+2 Program.** The Del E. Webb School of Construction also participates in the ASU 3+2 program with Grand Canyon University and Southwestern University. See page 271 for details.

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

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

### ADMISSION

See pages 47–52 and 63–64 for information regarding requirements for admission, transfer, retention, qualification, and reinstatement. A preprofessional category is available for applicants deficient in regular admission requirements. Vocational and craft-oriented courses taught at the community colleges are not accepted for credit toward a bachelor's degree in Construction.

### BASIC REQUIREMENTS

Students complete the following basic requirements before registering for advanced courses: (1) all first-semester, first-year courses and the university First-Year Composition requirement (see page 66) must be completed by the time the student has accumulated 48 semester hours of program requirements, and (2) all second-semester, first-year courses must be completed by the time the student has completed 64 semester hours of program requirements. Transfer students are given a one-semester waiver.

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

### DEGREE REQUIREMENTS

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

### GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy the General Studies requirements as noted on pages 71–74 and all university graduation requirements as noted on pages 66–70.

**SCHOOL COURSE REQUIREMENTS**

The Del E. Webb School of Construction requires that the General Studies requirement be satisfied in the following manner:

*Literacy and Critical Inquiry*

COM 225	Public Speaking L1.....	3
ETC 400	Technical Communications L2 .....	3

*Numeracy*

MAT 270	Calculus with Analytical Geometry I NI.....	4
	or MAT 260 Technical Calculus I NI (3) and MAT 261 Technical Calculus II (3)	
STP 226	Elements of Statistics N2.....	3

*Humanities and Fine Arts and Social and Behavioral Sciences*

CON 101	Construction and Culture: A Built Environment HU, G .....	3
ECN 111	Macroeconomic Principles SB .....	3
ECN 112	Microeconomic Principles SB .....	3
HU, SB, and	awareness area courses as needed .....	3-6

*Natural Sciences*

PHY 111	General Physics S1/S2 <sup>1</sup> .....	3
PHY 112	General Physics S1/S2 <sup>2</sup> .....	3
PHY 113	General Physics Laboratory S1/S2 <sup>1</sup> .....	1
PHY 114	General Physics Laboratory S1/S2 <sup>2</sup> .....	1

Total<sup>3</sup>..... 36

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

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

<sup>3</sup> Because of the school's requirement for MAT 270 (or MAT 260 and 261), the total semester hours exceeds the General Studies requirement of 35.

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

ACC 294	Survey of Accounting.....	3
CEE 310	Testing of Materials for Construction.....	3
CEE 340	Hydraulics and Hydrology .....	3
CEE 450	Soil Mechanics in Construction .....	3
CON 221	Applied Engineering Mechanics: Statics.....	3

CON 243	Heavy Construction Equipment, Methods, and Materials .....	3
CON 251	Microcomputer Applications for Construction.....	3
CON 252	Building Construction Methods, Materials, and Equipment.....	3
CON 273	Electrical Construction Fundamentals .....	3
CON 323	Strength of Materials.....	3
CON 341	Surveying .....	3
CON 345	Mechanical Systems .....	3
CON 371	Construction Management and Safety.....	3
CON 383	Construction Estimating.....	3
CON 389	Construction Cost Accounting and Control N3 .....	3
CON 424	Structural Design.....	3
CON 453	Construction Labor Management .....	3
CON 463	Foundations and Concrete Structures.....	3
CON 495	Construction Planning and Scheduling N3 .....	3
CON 496	Construction Contract Administration.....	3
ECE 100	Introduction to Engineering Design N3 .....	4
LES 306	Business Law.....	3
	Science elective with lab .....	4
	Upper-division technical elective.....	3
	Total common to all options.....	74

**Construction Options**

<b>General Building Construction</b>		
CON 472	Development Feasibility Reports L2 .....	3
CON 483	Advanced Building Estimating.....	3
LES 411	Real Estate Law.....	3
REA 394	Real Estate Fundamentals .....	3
	Total .....	12

<b>Heavy Construction</b>		
CON 344	Route Surveying.....	3
CON 486	Heavy Construction Estimating.....	3
	Upper-division technical electives .....	6
	Total .....	12

<b>Residential Construction</b>		
CON 377	Residential Construction Production Procedures.....	3
CON 477	Residential Construction Business Practices .....	3
LES 411	Real Estate Law.....	3
MKT 300	Principles of Marketing.....	3
	Total .....	12

<b>Specialty Construction</b>		
CON 455	Construction Office Methods .....	3

CON 468	Conceptual and Electrical Estimating.....	3
	Upper-division technical electives .....	6
	Total .....	12

**Military Option**

CON 344	Route Surveying.....	3
CON 486	Heavy Construction Estimating.....	3
	Approved military science courses.....	18
	Total .....	24

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

The course work for the first two years is the same for the general building, heavy, and speciality construction options. The specific lower-division requirements are shown below:

**First Semester**

CON 101	Construction and Culture: A Built Environment HU,G .....	3
ECN 111	Macroeconomic Principles SB .....	3
ENG 101	First-Year Composition.....	3
MAT 270	Calculus with Analytical Geometry N1 .....	4
PHY 111	General Physics S1/S2 <sup>1</sup> .....	3
PHY 113	General Physics Laboratory S1/S2 <sup>1</sup> .....	1
	Total .....	17

**Second Semester**

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

**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
STP 226	Elements of Statistics N2.....	3
	Basic science elective with lab.....	4
	Total .....	16

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71-94. For graduation requirements, see pages 66-70. Omnibus courses are offered that are not listed in the catalog; see pages 44-45.

**Fourth Semester**

ACC 294	Survey of Accounting.....	3
COM 225	Public Speaking <i>L1</i> .....	3
CON 252	Building Construction Methods, Materials, and Equipment.....	3
CON 273	Electrical Construction Fundamentals .....	3
CON 323	Strength of Materials.....	3
Total .....		15

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

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

**Option in General Building Construction**

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

**Requirements**

CON 472	Development Feasibility Reports <i>L2</i> .....	3
CON 483	Advanced Building Estimating.....	3
LES 411	Real Estate Law.....	3
REA 394	Real Estate Fundamentals .....	3
Total .....		12

**Option in Heavy Construction**

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

**Requirements**

CON 344	Route Surveying.....	3
CON 486	Heavy Construction Estimating.....	3
Upper-division technical elective.....		6
Total .....		12

**Option in Military Construction**

The military construction option is open only to students in the four-year ROTC program leading to a commis-

sion in the U.S. Armed Forces. The option prepares students for careers in the military construction field. Selected courses in the core have been replaced by military science courses.

**Requirements**

CON 344	Route Surveying.....	3
CON 486	Heavy Construction Estimating.....	3
Approved military science courses.....		18
Total .....		24

**Option in Residential Construction**

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

**Requirements**

CON 377	Residential Construction Production Procedures.....	3
CON 477	Residential Construction Business Practices .....	3
LES 411	Real Estate Law.....	3
MKT 300	Principles of Marketing.....	3
Total .....		12

**Option in Specialty Construction**

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

**Requirements**

CON 455	Construction Office Methods .....	3
CON 468	Conceptual and Electrical Estimating .....	3
Upper-division technical electives .....		6
Total .....		12

**CONSTRUCTION****CON 101 Construction and Culture: A Built Environment.** (3) F, S

An analysis of the cultural context of construction, emphasizing its centrality in the evolution and expansion of built environments as expressions of ethical and historical value systems. Lecture, speakers, field trips. *General Studies: HU, G.*

**221 Applied Engineering Mechanics: Statics.** (3) F, S

Vectors, forces and moments, force systems, equilibrium, analysis of basic structures and structural components, friction, centroids, and moments of inertia. Prerequisite: MAT 270.

**243 Heavy Construction Equipment, Methods, and Materials.** (3) F, S

Emphasis on "Horizontal" construction. Fleet operations, maintenance programs, methods, and procedures to construct tunnels, roads,

dams, and the excavation of buildings. Lab, field trips.

**244 Construction Graphics.** (2) F, S

Sketching and architectural drafting of building materials and systems. Computer graphic applications for construction. Lecture, lab, field trips. Prerequisite: ECE 100.

**251 Microcomputer Applications for Construction.** (3) F, S

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

**252 Building Construction Methods, Materials, and Equipment.** (3) F, S

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

**273 Electrical Construction Fundamentals.** (3) F, S

Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Field trips. Prerequisites: MAT 270 or equivalent; PHY 112, 114.

**323 Strength of Materials.** (3) F, S

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

**341 Surveying.** (3) F, S

Theory and field work in construction and land surveys. Lecture, lab. Prerequisite: MAT 170.

**344 Route Surveying.** (3) S

Simple, compound, and transition curves, including reconnaissance, preliminary, and location surveys. Calculation of earthwork. Dimensional control for construction projects. Lecture, lab. Prerequisites: CON 243, 341.

**345 Mechanical Systems.** (3) F, S

Design parameters and equipment related to heating and cooling systems for mechanical construction. Computer-aided calculations. Lecture, field trips. Prerequisites: CON 252; PHY 111, 113.

**371 Construction Management and Safety.** (3) F, S

Organization and management theory applied to the construction process. Leadership functions. Safety procedures and equipment. OSHA requirement for construction. Prerequisite: Junior standing.

**377 Residential Construction Production Procedures.** (3) F

The process used in residential construction. How a house is built: design, permits, scheduling, codes, contracting, site management, mechanical/electrical. Prerequisite: CON 252.

**383 Construction Estimating.** (3) F, S

Methods, techniques, and organizational approaches to construction quantity surveys for cost estimating. Microcomputer usage for estimating and bid preparation. Lecture, project workshops. Prerequisites: CON 243, 251, 252, 273; construction major or instructor approval.

**389 Construction Cost Accounting and Control.** (3) F, S

Nature of construction cost. Depreciation and tax theory and variable equipment costs. Cash flow theory, investment models, profitability, and analysis. Computer applications. Funding sources and arrangements. Builder's insur-

ance. Prerequisites: ACC 294 ST: Survey of Accounting; CON 251. *General Studies: N3.*

**424 Structural Design.** (3) F, S  
Economic use of steel, reinforced concrete, and wood in building and engineered structures. Design of beams, columns, and connections. Elastic and ultimate strength design. Student design projects. Field trips. Prerequisite: CON 323.

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

**455 Construction Office Methods.** (3) F, S  
Administrative systems and procedures for the construction company office, including methods improvement and work simplification, policy and procedures. Prerequisite: CON 389.

**463 Foundations and Concrete Structures.** (3) F, S  
Subsurface construction theory and practice for foundations of buildings, engineered facilities, shallow and deep foundations, pavements, and excavations. Concrete form design. Lecture, recitation, field trips. Prerequisites: CEE 450; CON 424.

**468 Conceptual and Electrical Estimating.** (3) F  
System of estimating construction costs before design has been initiated. Cost estimating for large projects. Analysis and organization of electrical estimate. Prerequisite: CON 383.

**472 Development Feasibility Reports.** (3) S  
Integration of economic location theory, development cost data, market research data, and financial analysis into a feasibility report. Computer orientation. Prerequisites: CON 389; REA 394 ST: Real Estate Fundamentals. *General Studies: L2.*

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

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

**486 Heavy Construction Estimating.** (3) F, S  
Methods analysis and cost estimation for construction of highways, bridges, tunnels, dams, and other engineering works. Field trips. Prerequisite: CON 383. Pre- or corequisite: CON 344.

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

**496 Construction Contract Administration.** (3) F, S  
Survey administrative procedures of the general and subcontractors. Study documentation, claims, arbitration, litigation, bonding, insurance, and indemnification. Discuss ethical practices. Lecture, field trips. Prerequisites: CON 371; ETC 400; senior standing.

**512 Advanced Construction Contract Administration.** (3) F, S  
Advanced studies in construction contract administration. Survey the administrative procedures of the general and subcontractor. Study documentation, claims, arbitration, litigation, bonding, insurance, indemnification, legal practice, licensing, codes. Lecture, guest speakers, field trips.

**531 Economics of the Construction Industries.** (3) F  
The economic environment of construction, with emphasis on unique aspects; critical review of economic literature dealing with the construction industries. Prerequisite: CON 496 or instructor approval.

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

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

**543 Construction Equipment Engineering.** (3) S  
Analysis of heavy construction equipment productivity using case studies. Applies engineering fundamentals to the planning, selection, and utilization of equipment. Lecture, case studies.

**545 Construction Project Management.** (3) S  
Theory and practice of construction project management. Roles of designer, owner, general contractor, and construction manager. Lecture, field trips. Pre- or corequisite: CON 495.

**547 Strategic Planning.** (3) S  
The business planning process of the construction enterprise. Differences between publicly held and closely held businesses and their exposure.

**548 Managing the Construction Enterprise for Survival.** (3) F  
Provides a thorough understanding of the business risks in the construction industry, and processes for avoiding them.

**551 Facilities Management.** (3) S  
Analysis of the facilities management organization and implementation of human resources, business management, building design and construction, work management, and physical plant operations.

**577 Construction Systems Engineering.** (3) F  
Systems theory as applied to the construction process. Alternates for structuring information

flows and the control of projects. Prerequisite: IEE 476 or equivalent.

**561 International Construction.** (3) S  
An investigation of the cultural, social, economic, political, and management issues related to construction in foreign countries and remote regions.

**589 Construction Company Financial Control.** (3) F  
Financial accounting and cost control at the company level in construction companies. Accounting systems. Construction project profit calculations. Financial analysis. Lecture, case studies.

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## School of Engineering

(ECG 104) 602/965-1726

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### PURPOSE

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

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

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

1. those who wish to pursue a career in engineering;
2. those who wish to do graduate work in engineering;

- those who wish to have one or two years of training in mathematics, applied science, and engineering in preparation for some other technical career;
- those who desire pre-engineering for the purpose of deciding which program to undertake or those who desire to transfer to another college or university; and
- those who wish to take certain electives in engineering while pursuing another program in the university.

### ADMISSION

See pages 47–52, 63–64, 264–265, and 270 for information regarding requirements for admission, transfer, retention, disqualification, and reinstatement.

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

### DEGREES AND MAJORS

The Bachelor of Science (B.S.) and Bachelor of Science in Engineering (B.S.E.) degrees are composed of three parts:

- university requirements (e.g., General Studies, First-Year Composition);
- an engineering core; and
- 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 Engi-

neering and Technology (ABET), for programs in engineering.

In addition to First-Year Composition, the university requires, under the heading of General Studies, courses in literacy and critical inquiry, humanities and fine arts, social and behavioral sciences, numeracy, and natural sciences (see pages 71–74). There are also requirements in historical and global awareness, and in cultural diversity in the United States. ABET imposes additional requirements, particularly in mathematics and the basic sciences and in the courses for the major.

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

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

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

Majors and areas of emphasis are offered by the six engineering departments: Chemical, Bio and Materials Engineering; Civil and Environmental Engineering; Computer Science and Engineering; Electrical Engineering; Industrial and Management Systems Engineering; and Mechanical and Aerospace Engineering. The major in Engineering Special Studies is administered by the Office of the Dean. Engineering Special Studies makes use of the general

structure of the engineering curricula noted above and provides students with an opportunity for study in engineering options not available in the traditional engineering curricula at ASU.

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

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

#### Typical Freshman Year

##### First Semester

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

##### Second Semester

ECN	111	Macroeconomic Principles SB .....	3
		or ECN 112 Microeconomic Principles SB (3)	
ENG	102	First-Year Composition.....	3
MAT	271	Calculus with Analytic Geometry II .....	4
PHY	121	University Physics I: Mechanics S1/S2* .....	3
PHY	122	University Physics Laboratory I S1/S2*.....	1
HU, SB, and awareness area courses .....			3
Total .....			18

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

Well-prepared students who have no outside commitments can usually complete the program of study leading to an undergraduate degree in engineering in four years (eight semesters at 16 semester hours per semester). Many students, however, find it advantageous or necessary to devote more than four years to the undergraduate program by pursuing, in any semester, fewer studies than are regularly prescribed. Where omissions or deficiencies exist, e.g., in

chemistry, computer programming, English, mathematics, and physics, the student must complete more than the minimum of 128 semester hours. Therefore, in cases of inadequate secondary preparation, poor health, or financial necessity requiring considerable time for outside work, the undergraduate program is extended beyond four years.

**DEGREE REQUIREMENTS**

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

1. *Oral and written English.* Communication skills are an essential component of an engineering education. All engineering students must complete the university First-Year Composition requirement (see page 66) and the literacy and critical inquiry component (see page 72) of the General Studies requirement, which involves two courses beyond First-Year Composition.
2. *Selected non-engineering topics.* This area ensures that the engineering student acquires a satisfactory level of basic knowledge in the humanities and fine arts, social and behavioral sciences, numeracy, and the natural sciences. Courses in these subjects give engineers an increased awareness of their social responsibilities, provide an understanding of related factors in the decision-making process, and also provide a foundation for the study of engineering. Required courses go toward fulfilling the General Studies requirement. Additional courses in mathematics and the basic sciences are selected to meet ABET requirements. *Because of accreditation requirements, aerospace studies (AES) and military science (MIS) courses are not acceptable for engineering degree credit in fulfilling the hu-*

*manities and fine arts and social and behavioral science portions of the General Studies requirement.*

3. *Selected engineering topics.* This area involves courses in engineering science and engineering design. The courses further develop the foundation for the study of engineering and provide the base for specialized studies in a particular engineering discipline. The specific courses are included in the engineering core and in the major. While some departmental choices are allowed, all students are required to take ECE 100 Introduction to Engineering Design and ECE 300 Intermediate Engineering Design as part of the engineering core. These courses, together with other experiences in the engineering core and in the major, serve to integrate the study of design, the “process of devising a system, component, or process to meet desired needs” (ABET), throughout the engineering curricula.
4. *Specific engineering discipline.* This area provides a depth of understanding of a more definitive body of knowledge that is appropriate for a specific engineering discipline. Courses build upon the background provided by the earlier completed portions of the curriculum and include a major design experience as well as technical electives that may be selected by the student with the assistance of an adviser. The catalog material for the individual engineering majors describes specific departmental requirements.

**B.S. and B.S.E. Course Requirements**

The specific course requirements for the B.S. and B.S.E. degrees are listed below.

**First-Year Composition**

ENG 101, 102	First-Year Composition .....	6
	or ENG 105	
	Advanced First-Year Composition (3)	

**General Studies/School Requirements**

<i>Literacy and Critical Inquiry</i> (Six semester hours minimum)		
ECE 300	Intermediate Engineering Design L1 .....	3

ECE 400	Engineering Communications L2 .....	3
	or approved department L2 course (3)	
<i>Numeracy/Mathematics</i>		
ECE 100	Introduction to Engineering Design N3.....	4
MAT 270	Calculus with Analytic Geometry I N1.....	4
MAT 271	Calculus with Analytic Geometry II .....	4
MAT 272	Calculus with Analytic Geometry III.....	4
MAT 274	Elementary Differential Equations.....	3
	Department mathematics elective .....	2
<i>Humanities and Fine Arts and Social and Behavioral Sciences</i> <sup>1</sup> (16 semester hours minimum)		
ECN 111	Macroeconomic Principles SB .....	3
	or ECN 112 Microeconomic Principles SB (3)	
	HU course(s) <sup>1</sup> .....	6–10
	SB course(s) <sup>1</sup> .....	3–7
<i>Natural Sciences/Basic Sciences</i>		
CHM 114	General Chemistry for Engineers S1/S2.....	4
	or CHM 116 General Chemistry S1/S2 (4)	
PHY 121	University Physics I: Mechanics S1/S2 <sup>2</sup> .....	3
PHY 122	University Physics Laboratory I S1/S2 <sup>2</sup> .....	1
PHY 131	University Physics II: Electricity and Magnetism S1/S2 <sup>3</sup> .....	3
PHY 132	University Physics Laboratory II S1/S2 <sup>3</sup> .....	1
	Department basic science elective.....	3
Total General Studies/school requirements .....		58

<sup>1</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements, as described on this page.

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

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

**Engineering Core**

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

ECE 210	Engineering Mechanics I: Statics .....	3
ECE 301	Electrical Networks I.....	4
ECE 312	Engineering Mechanics II: Dynamics.....	3

ECE	313	Introduction to Deformable Solids.....	3
ECE	334	Electronic Devices and Instrumentation.....	4
ECE	340	Thermodynamics.....	3
		or CHM 441 General Physical Chemistry (3)	
ECE	350	Structure and Properties of Materials .....	3
		or CHM 442 General Physical Chemistry (3)	
		or ECE 351 Engineering Materials (3)	
		or ECE 352 Properties of Electronic Materials (4)	
		Microcomputer/Microprocessor course .....	3-4
BME	470	Microcomputer Applications in Bioengineering (4)	
CHE	461	Process Control N3 (4)	
CSE/EEE	225	Assembly Language Programming and Microprocessors (Motorola) N3 (4)	
CSE/EEE	226	Assembly Language Programming and Microprocessors (Intel) N3 (4)	
IEE	463	Computer-Aided Manufacturing and Control N3 (3)	
		Total required minimum engineering core .....	15-19
		A summary of the degree requirements is as follows:	
		First-Year Composition.....	6
		General Studies/School Requirements .....	58
		Engineering core.....	15-19
		Major (including area of emphasis).....	45-49
		The requirements for each of the majors offered are described on the following pages.	
		Total degree requirements.....	128

## GRADUATION REQUIREMENTS

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

## PROFESSIONAL ACCREDITATION

The undergraduate programs in Aerospace Engineering, Bioengineering, Chemical Engineering, Civil Engineering, Computer Systems Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, and Engineering Special Studies are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology

(ABET). Engineering Special Studies is accredited under the nontraditional program criteria. The Bachelor of Science program in Computer Science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB).

## ANALYSIS AND SYSTEMS

### ASE 100 College Adjustment and Survival. (2) F, S

Exploration of career goals and majors. Emphasis on organization and development of study skills, including time management, stress management, and use of the library.

### 399 Cooperative Work Experience. (1) F, S, SS

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

### 485 Engineering Statistics. (3) F, S, SS

Designing statistical studies for solutions to engineering problems. Methods include regression, design and analysis of experiments, and other statistical topics. Prerequisite: ECE 380. *General Studies: N2.*

### 490 Project in Design and Development. (2-3) F, S, SS

Individual project in creative design and synthesis. Course may be repeated. Prerequisite: senior standing.

### 496 Professional Seminar. (0) F, S

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

### 500 Research Methods: Engineering Statistics. (3) F, S, SS

Designing statistical studies for solutions to engineering problems. Methods include regression, design and analysis of experiments, and other statistical topics. Prerequisite: ECE 380.

### 582 Linear Algebra in Engineering. (3) F

Development and solution of systems of linear algebraic equations. Applications from mechanical, structural, and electrical fields of engineering. Prerequisite: MAT 242 or equivalent.

### 586 Partial Differential Equations in Engineering. (3) S

Development and solution of partial differential equations in engineering. Applications in solid mechanics, vibrations, and heat transfer. Prerequisites: ECE 386; MAT 242, 274.

## ENGINEERING CORE

### ECE 100 Introduction to Engineering Design. (4) F, S

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

### 210 Engineering Mechanics I: Statics. (3) F, S, SS

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

### 300 Intermediate Engineering Design. (3) F, S

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

### 301 Electrical Networks I. (4) F, S, SS

Introduction to electrical networks. Component models, transient, and steady-state analysis. Lecture, lab. Prerequisite: ECE 100. Pre- or corequisites: MAT 274; PHY 131, 132.

### 312 Engineering Mechanics II: Dynamics. (3) F, S, SS

Kinematics and kinetics of particles, translating and rotating coordinate systems, rigid body kinematics, dynamics of systems of particles and rigid bodies, and energy and momentum principles. Lecture, recitation. Prerequisites: ECE 210; MAT 274.

### 313 Introduction to Deformable Solids. (3) F, S, SS

Equilibrium, strain-displacement relations, and stress-strain-temperature relations. Applications to force transmission and deformations in axial, torsional, and bending of bars. Combined loadings. Lecture, recitation. Prerequisites: ECE 210; MAT 274.

### 334 Electronic Devices and Instrumentation. (4) F, S, SS

Application of electric network theory to semiconductor circuits. Diodes/transistors/amplifiers/opamps/digital logic gates, and electronic instruments. Lecture, lab. Prerequisite: ECE 301.

### 340 Thermodynamics. (3) F, S, SS

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

### 350 Structure and Properties of Materials. (3) F, S, SS

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

### 351 Engineering Materials. (3) F, S

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

### 352 Properties of Electronic Materials. (4) F, S, SS

Schrodinger's wave equation, potential barrier problems, bonds of crystals, the band theory of solids, semiconductors, superconductor dielectric, and magnetic properties. Prerequisites: MAT 274; PHY 252.

### 380 Probability and Statistics for Engineering Problem Solving. (3) F, S

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

**384 Numerical Analysis for Engineers I.** (2) F, S

Numerical solution of algebraic and transcendental equations and systems of linear equations. Numerical integration. Curve fitting. Error bounds and error propagation. Emphasis on use of digital computer. Prerequisite: MAT 272 or 291.

**385 Numerical Analysis for Engineers II.** (2) S

Continuation of ECE 384. Numerical solution of partial differential equations and mixed equation systems. Introduction to experimental design and optimization techniques. Prerequisite: ECE 384.

**386 Partial Differential Equations for Engineers.** (2) F, S

Boundary value problems, separation of variables, and Fourier series as applied to initial-boundary value problems. Prerequisite: MAT 274.

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

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

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**SOCIETY, VALUES,  
AND TECHNOLOGY**

**STE 201 Introduction to Bioengineering.** (3) F

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

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**Department of  
Chemical, Bio and  
Materials Engineering**

**Eric J. Guilbeau  
Chair  
(ECG 202) 602/965-3313**

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

Chemical engineers design and operate processes that may include chemical change. They combine the science

of chemistry with the discipline of engineering in order to solve complex problems in a wide variety of industries. Challenging job opportunities exist not only in the chemical and petroleum industries, but also in the plastics, electronics, computer, metals, space, food, drug, and health care industries.

In these industries, chemical engineers practice in a wide variety of occupations including environmental control, surface treatments, energy and materials transformation, biomedical applications, fermentation, protein recovery, extractive metallurgy, and separations. In the environmental area, chemical engineers develop methods to reduce the pollution created in manufacturing processes, devise techniques to recover usable materials from wastes, design waste storage and treatment facilities, and design pollution control strategies.

Bioengineering (synonyms: biomedical engineering or medical engineering) is the discipline of engineering that applies principles and methods from engineering, the life sciences, and the medical sciences to understand, define, and solve problems in medicine, physiology, and biology. Bioengineering students typically pursue either a career in the medical-device/biotechnology industry or a career in bioengineering, medical or biotechnology research or enter a post graduate program in clinical or veterinary medicine or dentistry. The practicing bioengineer uses engineering principles and technology to develop instrumentation, biomaterials, diagnostic and therapeutic devices, artificial organs, and other equipment needed in medicine and biology. They also discover new fundamental principles regarding the functioning and structure of living systems.

Materials science and engineering is the engineering and scientific discipline that is concerned with the study of fundamental relationships between the structure and processing of materials and their properties. Students educated in this discipline are prepared to make decisions concerning the optimum utilization of existing materials or to develop and process new advanced materials. Students who major in materials science and engineering will find employment opportunities in a variety of industries and research facilities associ-

ated with industries of aerospace, solid-state electronics, energy conversion, transportation, manufacturing, and chemical processing.

The following sections describe the curriculum requirements for the Bachelor of Science degree in each of these disciplines. Faculty within the department also participate in the Engineering Special Studies program in premedical engineering which is described separately on pages 319-320.

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**CHEMICAL ENGINEERING—  
B.S.E.**

**PROFESSORS**

BERMAN, CALE, GUILBEAU, HENRY, KUESTER, RAUPP, SATER, ZWIEBEL

**ASSOCIATE PROFESSORS**

BECKMAN, BELLAMY, BURROWS, GARCIA, RIVERA, TORREST

**ASSISTANT PROFESSOR**

BEAUDOIN

**PROFESSOR EMERITUS**

REISER

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

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

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

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

### DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. in Chemical Engineering degree.

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

#### English Proficiency (6)

ENG 101, 102	First-Year Composition .....	6
	or ENG 105	
	Advanced First-Year Composition (3)	

#### General Studies/School Requirements (59)

##### Literacy and Critical Inquiry

The General Studies program and the B.S.E. in Chemical Engineering degree require six semester hours in Literacy and Critical Inquiry.

ECE 300	Intermediate Engineering Design <i>L1</i> .....	3
CHE 352	Transport Laboratories <i>L1</i> .....	3

##### Numeracy/Mathematics

The General Studies program requires six semester hours in Numeracy; however, the B.S.E. in Chemical Engineering degree requires 21 semester hours in Numeracy/Mathematics.

ECE 100	Introduction to Engineering Design <i>N3</i> .....	4
ECE 384	Numerical Analysis for Engineers I .....	2
MAT 270	Calculus with Analytic Geometry I <i>N1</i> .....	4
MAT 271	Calculus with Analytic Geometry II .....	4
MAT 272	Calculus with Analytic Geometry III.....	4
MAT 274	Elementary Differential Equations.....	3

##### Humanities and Fine Arts and Social and Behavioral Sciences (16)<sup>1</sup>

The General Studies program requires 15 semester hours in Humanities and Fine Arts and Social and Behavioral Sciences courses; however, the B.S.E. in Chemical Engineering degree requires 16 semester hours.

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

##### Natural Sciences/Basic Sciences

The General Studies program requires eight semester hours in Natural Sciences courses; however, the B.S.E. in Chemical Engineering degree requires 16 semester hours in Natural Sciences/Basic Sciences.

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

#### Engineering Core (20)

CHE 342	Applied Chemical Thermodynamics.....	4
CHE 461	Process Control <i>N3</i> .....	4
ECE 394	ST: Conservation Principles..	4
ECE 394	ST: Properties that Matter .....	4
ECE 394	ST: Systems.....	4

#### Major (43)

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

<sup>1</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 277.

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

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

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

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

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

### Chemical Engineering Areas of Emphasis

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

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

#### Chemistry Electives

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

**Technical Electives**

AGB 423	Food and Industrial Microbiology.....	4
AGB 424	Food and Industrial Fermentations .....	4
AGB 425	Food Safety .....	3
AGB 426	Food Chemistry .....	4
CHE 475	Biochemical Engineering .....	3
CHE 476	Bioreaction Engineering.....	3
CHE 477	Bioseparation Processes .....	3

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

**Chemistry Electives**

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

**Technical Electives**

BME 318	Biomaterials .....	3
BME 411	Biomedical Engineering I.....	3
BME 412	Biomedical Engineering II .....	3
BME 413	Biomedical Instrumentation I .....	3
BME 414	Biomedical Measurements .....	3
BME 435	Physiology for Engineers .....	4

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

**Chemistry Electives**

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

**Technical Electives**

CEE 361	Introduction to Environmental Engineering...	4
CEE 362	Environmental Engineering...	3
CEE 561	Physical-Chemical Treatment of Water and Waste .....	3
CEE 563	Environmental Chemistry Laboratory .....	3
CHE 494	Special Topics .....	1-4
CHE 533	Transport Processes I.....	3
CHE 552	Industrial Water Quality Engineering .....	3
CHE 553	Air Quality Control .....	3
EEE 461	Health Physics Principles and Radiation Measurements.....	3

CHE 552 Industrial Water Quality Engineering (3) and CHE 553 Air Quality Control (3) are available to juniors and seniors with appropriate approvals.

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

**Chemistry Electives**

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

**Technical Electives**

BME 318	Biomaterials .....	3
CHE 458	Semiconductor Material Processing.....	3
ECE 352	Properties of Electronic Materials.....	4
MSE 353	Introduction to Materials Processing and Synthesis .....	3
MSE 354	Experiments in Materials Synthesis and Processing I .....	2
MSE 431	Corrosion and Corrosion Control.....	3
MSE 453	Experiments in Materials Synthesis and Processing II.....	2
MSE 454	Advanced Materials Processing and Synthesis .....	3
MSE 470	Polymers and Composites .....	3

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

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

**Energy Conversion and Conservation**

CHM 528	Process Optimization Techniques .....	3
CHE 554	New Energy Technology.....	3
CHE 556	Separation Processes .....	3
MAE 436	Combustion .....	3
MAE 437	Direct Energy Conversion.....	3
MAE 438	Solar Energy.....	3

**Plant Administration and Management**

CHE 528	Process Optimization Techniques .....	3
CHE 553	Air Quality Control .....	3
IEE 300	Economic Analysis for Engineers.....	3
IEE 431	Engineering Administration .....	3

**Simulation, Control, and Design**

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

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

**Chemistry Elective**

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

**Technical Electives**

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

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

**First Semester**

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

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71-94. For graduation requirements, see pages 66-70. Omnibus courses are offered that are not listed in the catalog; see pages 44-45.

**Second Semester**

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

**Second Year****First Semester**

CHE 311	Introduction to Chemical Processing.....	3
ECE 380	Probability and Statistics for Engineering Problem Solving.....	3
ECE 394	ST: Conservation Principles..	4
MAT 274	Elementary Differential Equations.....	3
HU or SB elective	.....	3
Total	.....	16

**Second Semester**

CHE 331	Transport Phenomena I: Fluids.....	3
ECE 300	Intermediate Engineering Design L1 .....	3
ECE 394	ST: Properties that Matter .....	4
MAT 272	Calculus with Analytic Geometry III.....	4
HU or SB elective	.....	4
Total	.....	18

**Third Year****First Semester**

CHE 332	Transport Phenomena II: Energy Transfer.....	3
CHE 342	Applied Chemical Thermodynamics.....	4
CHM 331	General Organic Chemistry...	3
CHM 335	General Organic Chemistry Laboratory .....	1
ECE 384	Numerical Analysis for Engineers I .....	2
HU or SB elective	.....	3
Total	.....	16

**Second Semester**

CHE 333	Transport Phenomena III: Mass Transfer .....	3
CHE 352	Transport Laboratories L1.....	3
CHE 432	Principles of Chemical Engineering Design .....	3
CHM 332	General Organic Chemistry...	3
ECE 385	Numerical Analysis for Engineers II.....	2
ECE 394	ST: Systems.....	4
Total	.....	18

**Fourth Year****First Semester**

CHE 442	Chemical Reactor Design.....	3
CHE 451	Chemical Engineering Laboratory .....	2

CHE 461	Process Control N3.....	4
HU, SB, and awareness area courses	.....	3
Technical elective.....	.....	3
Total	.....	15

**Second Semester**

CHE 462	Process Design .....	3
HU, SB, and awareness area courses	.....	3
Technical elective.....	.....	9
Total	.....	15

*Degree requirements: 128 semester hours.*

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

**BIOENGINEERING—B.S.E.****PROFESSORS**

GUILBEAU, TOWE

**ASSOCIATE PROFESSORS**

HE, YAMAGUCHI

**ASSISTANT PROFESSORS**

KIPKE, PIZZICONI, SWEENEY

**PROFESSOR EMERITUS**

DORSON

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

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

ogy industry, a career in biomedical research, a career in biotechnology research, or entry into a medical college.

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

**DEGREE REQUIREMENTS**

A minimum of 128 semester hours is necessary for the B.S.E. in Bioengineering degree.

**GRADUATION REQUIREMENTS**

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

**COURSE REQUIREMENTS**

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

**English Proficiency (6)**

ENG 101, 102	First-Year Composition .....	6
	or ENG 105	
	Advanced First-Year Composition (3)	

**General Studies/School Requirements (60)***Literacy and Critical Inquiry (7)*

The General Studies program requires six semester hours in Literacy and Critical Inquiry; however, the B.S.E. in Bioengineering degree requires seven semester hours.

BME 413	Biomedical Instrumentation L2 .....	3
BME 423	Biomedical Instrumentation Laboratory L2.....	1
ECE 300	Intermediate Engineering Design L1 .....	3

*Numeracy/Mathematics*

The General Studies program requires six semester hours in Numeracy; however, the B.S.E. in Bioengineering degree requires 21 semester hours.

ECE 100	Introduction to Engineering Design N3.....	4
MAT 242	Elementary Linear Algebra N1 .....	2
	or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers I (2)	
MAT 270	Calculus with Analytic Geometry I N1.....	4

MAT 271	Calculus with Analytic Geometry II .....	4	ECE 380	Probability and Statistics for Engineering Problem Solving.....	3
MAT 272	Calculus with Analytic Geometry III.....	4		Technical electives .....	9
MAT 274	Elementary Differential Equations.....	3			
<i>Humanities and Fine Arts and Social and Behavioral Sciences</i> <sup>1</sup> (16)					
The General Studies program requires 15 semester hours in Humanities and Fine Arts and Social and Behavioral Sciences courses; however, the B.S.E. in Bioengineering degree requires 16 semester hours.					
ECN 111	Macroeconomic Principles <i>SB</i> .....	3			
	or ECN 112 Microeconomic Principles <i>SB</i> (3)				
SB, HU, and awareness area courses .....13					
<i>Natural Sciences/Basic Sciences</i>					
The General Studies program requires eight semester hours in Natural Sciences; however, the B.S.E. in Bioengineering degree requires 16 semester hours in Natural Sciences/Basic Sciences.					
CHM 113	General Chemistry <i>S1/S2</i> .....	4			
CHM 116	General Chemistry <i>S1/S2</i> .....	4			
PHY 121	University Physics I: Mechanics <i>S1/S2</i> <sup>2</sup> .....	3			
PHY 122	University Physics Laboratory I <i>S1/S2</i> <sup>2</sup> .....	1			
PHY 131	University Physics II: Electricity and Magnetism <i>S1/S2</i> <sup>3</sup> .....	3			
PHY 132	University Physics Laboratory II <i>S1/S2</i> <sup>3</sup> .....	1			
<b>Engineering Core</b> (17)					
ECE 210	Engineering Mechanics I: Statics .....	3			
ECE 301	Electrical Networks I.....	4			
ECE 334	Electronic Devices and Instrumentation.....	4			
ECE 340	Thermodynamics.....	3			
ECE 350	Structure and Properties of Materials .....	3			
<b>Major</b> (45)					
BIO 181	General Biology <i>S1/S2</i> .....	4			
BME 201	Introduction to Bioengineering <i>L1</i> .....	3			
BME 318	Biomaterials .....	3			
BME 331	Biomedical Engineering Transport I: Fluids.....	3			
BME 334	Bioengineering Heat and Mass Transfer .....	3			
BME 416	Biomechanics .....	3			
BME 417	Biomedical Engineering Capstone Design I .....	3			
BME 435	Physiology for Engineers .....	4			
BME 470	Microcomputer Applications in Bioengineering .....	4			
BME 490	Biomedical Engineering Capstone Design II .....	1-5			

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 emphasis. Technical electives must include the following:

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

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

ECE 384	Numerical Analysis for Engineers I.....	2
	or MAT 242 Elementary Linear Algebra <i>NI</i> (2)	

Technical electives must include the following:

ECE 312	Engineering Mechanics II: Dynamics.....	3
ECE 313	Introduction to Deformable Solids.....	3
BME 419	Biocontrol Systems .....	3

*Biomedical Imaging Engineering.* This emphasis is designed to strengthen the student's knowledge of radiation interactions, health physics, radiation biology, radiation protection, and nuclear instrumentation. Students considering careers in medical engineering or health physics should consider this area of emphasis. Technical electives include the following:

BME 419	Biocontrol Systems .....	3
BME 494	ST: Biomedical Digital Signal Processing .....	3
EEE 302	Electrical Networks II .....	3

*Biomaterials Engineering.* This area of emphasis integrates the student's knowledge of materials science and en-

BME 461	Health Physics Principles and Radiation Measurements .....	3
BME 465	Clinical Nuclear Engineering I .....	3
	or suitable upper-division medical imaging course	
PHY 361	Introductory Modern Physics.....	3

**Biosystems Engineering.** This emphasis is designed to strengthen the background of students interested in physiological systems analysis and design of artificial organs and other transport-based medical devices that are based on momentum, heat, or mass transfer phenomena. Analyzing or designing flowing and reacting systems requires a background in transport phenomena, thermodynamics, and reaction engineering. Students considering careers in the medical device industry or further studies in artificial organs should consider this area of emphasis. Technical electives must include the following:

BME 411	Biomedical Engineering I.....	3
	or BME 412 Biomedical Engineering II (3)	
BME 415	Biomedical Transport Processes .....	3
BME 419	Biocontrol Systems .....	3

The remaining technical elective must be an upper-division engineering course.

**Molecular and Cellular Bioengineering.** This emphasis is designed to strengthen and integrate the student's knowledge of molecular and cellular biology, biochemistry, and biomaterials science and engineering for the design of biomolecular and cellular-based hybrid medical and diagnostic devices. It is particularly suited for students inter-

ested in pursuing graduate studies in molecular and cellular bioengineering and health-related biotechnology. Technical electives must include the following:

BIO 332	Cell Biology .....	3
CHM 331	General Organic Chemistry.....	3
CHM 361	Principles of Biochemistry ....	3

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

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

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

**Bioengineering Program of Study  
Typical Four-Year Sequence**

**First Year**

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

**Second Semester**

CHM 116	General Chemistry <i>SI/S2</i> .....	4
ENG 102	First-Year Composition.....	3

MAT 271	Calculus with Analytic Geometry II .....	4
PHY 121	University Physics I: Mechanics <i>SI/S2</i> <sup>1</sup> .....	3
PHY 122	University Physics Laboratory I <i>SI/S2</i> <sup>1</sup> .....	1
Total		15

**Second Year**

**First Semester**

BIO 181	General Biology <i>SI/S2</i> .....	4
BME 201	Introduction to Bioengineering <i>LI</i> .....	3
ECE 210	Engineering Mechanics I: Statics .....	3
MAT 274	Elementary Differential Equations.....	3
PHY 131	University Physics II: Electricity and Magnetism <i>SI/S2</i> <sup>2</sup> .....	3
PHY 132	University Physics Laboratory II <i>SI/S2</i> <sup>2</sup> .....	1
Total		17

**Second Semester**

BME 331	Biomedical Engineering Transport I: Fluids.....	3
ECE 301	Electrical Networks I.....	4
MAT 272	Calculus with Analytic Geometry III.....	4
HU, SB, and awareness area courses <sup>3</sup>		6
Total		17

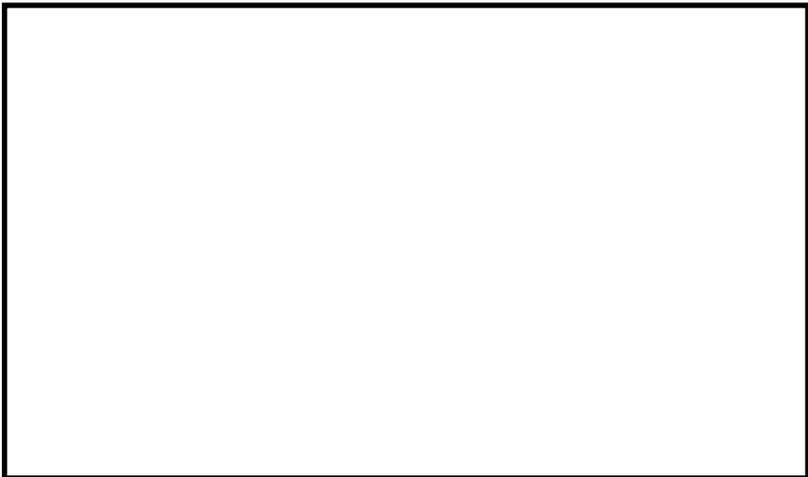
**Third Year**

**First Semester**

BME 435	Physiology for Engineers .....	4
ECE 300	Intermediate Engineering Design <i>LI</i> .....	3
ECE 340	Thermodynamics.....	3
ECE 350	Structure and Properties of Materials .....	3
ECN 111	Macroeconomic Principles <i>SB</i> .....	3
	or ECN 112 Microeconomic Principles <i>SB</i> (3)	
MAT 242	Elementary Linear Algebra <i>NI</i> .....	2
	or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	
Total		18

**Second Semester**

BME 318	Biomaterials .....	3
BME 334	Bioengineering Heat and Mass Transfer .....	3
ECE 334	Electrical Instrumentation and Devices .....	4
ECE 380	Probability and Statistics for Engineering Problem Solving.....	3
HU, SB, and awareness area courses <sup>3</sup>		4
Total		16



**Fourth Year****First Semester**

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

**Second Semester**

BME 470	Microcomputer Applications in Bioengineering .....	4
BME 490	Biomedical Engineering Capstone Design II .....	1-5
Technical electives .....		6
Total .....		13

*Degree requirements: 128 semester hours.*

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

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

<sup>3</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 277.

**MATERIALS SCIENCE AND ENGINEERING—B.S.E.****REGENTS' PROFESSOR  
MAYER****PROFESSORS  
CARPENTER, JACOBSON, KRAUSE****ASSOCIATE PROFESSOR  
DEY****ASSISTANT PROFESSOR  
ALFORD****PROFESSORS EMERITI  
HENDRICKSON, STANLEY, WAGNER**

Materials science is the engineering and scientific discipline that is concerned with the study of fundamental relationships between the structure of materials and their properties. The program provides students with the knowledge necessary to make decisions concerning the optimum utilization of existing materials or to develop and process new materials.

Essentially all major industries and many research laboratories are involved to some extent with the selection, utilization, and development of materials in designing and producing engineered systems. Students who major in Materials Science and Engineering find employment opportunities in a variety of industries and research facilities associated with aerospace, solid-state electronics, energy conversion, transportation, manufacturing and chemical processing. The responsibilities of a materials scientist or materials engineer include research and development of materials to meet some new demand brought about by advancing technology, to select the best choice of existing materials for a specific application, or to devise novel ways to process materials to improve performance. Materials scientists also develop new techniques for processing materials to reduce costs of products or to create new products. Also, materials scientists are often responsible for analyzing data on field tested materials to determine the effects of the environment on materials performance.

The tools of a materials scientist include highly sophisticated analytical and processing equipment. Instruments such as ion implanters, molecular beam epitaxy systems, and chemical vapor deposition chambers have become indispensable in materials processing. Since a considerable emphasis in materials science is placed on the microscopic world, instruments such as transmission and scanning electron microscopes, scanning tunneling microscopes, X-ray diffractometers, and Auger spectrometers are a necessary part of the field.

**DEGREE REQUIREMENTS**

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

**Graduation Requirements.** In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

**Course Requirements.** The undergraduate curriculum requires that students take a series of interdisciplinary

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

**English Proficiency (6)**

ENG 101, 102	First-Year Composition .....	6
or ENG 105		
Advanced First-Year Composition (3)		

**General Studies/School Requirements (59)***Literacy and Critical Inquiry*

The General Studies program and the B.S.E. in Materials Science and Engineering degree require six semester hours in Literacy and Critical Inquiry.

ECE 300	Intermediate Engineering Design L1 .....	3
ECE 400	Engineering Communications L2 .....	3

*Numeracy/Mathematics*

The General Studies program requires six semester hours in Numeracy; however, the B.S.E. in Materials Science and Engineering degree requires 21 semester hours.

ECE 100	Introduction to Engineering Design N3.....	4
MAT 242	Elementary Linear Algebra N1 .....	2
MAT 270	Calculus with Analytic Geometry I N1.....	4
MAT 271	Calculus with Analytic Geometry II .....	4
MAT 272	Calculus with Analytic Geometry III.....	4
MAT 274	Elementary Differential Equations.....	3

*Humanities and Fine Arts and Social and Behavioral Sciences<sup>1</sup>*

The General Studies program requires 15 semester hours in Humanities and Fine Arts and Social and Behavioral Sciences courses; however, the B.S.E. in Materials Science and Engineering degree requires 16 semester hours.

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

*Natural Sciences/Basic Sciences*

The General Studies program requires eight semester hours in Natural Sciences courses; however, the B.S.E. in Materials Science

and Engineering degree requires 16 semester hours.

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

#### Engineering Core (16)

ECE	210	Engineering Mechanics: Statistics .....	3
ECE	301	Electrical Networks I.....	4
ECE	313	Introduction to Deformable Solids.....	3
ECE	340	Thermodynamics.....	3
ECE	350	Structure and Properties of Materials .....	3

#### Major (47)

BME	331	Biomedical Engineering Transport I: Fluids.....	3
CHM	341	Elementary Physical Chemistry .....	3
CHM	343	Physical Chemistry Laboratory .....	1
ECE	380	Probability and Statistics for Engineering Problem Solving.....	3
ECE	394	ST: Conservation Principles..	4
MSE	353	Introduction to Materials Processing and Synthesis .....	3
MSE	354	Experiments in Materials Synthesis and Processing I .....	2
MSE	355	Introduction to Materials Science and Engineering .....	3
MSE	420	Physical Metallurgy.....	3
MSE	421	Physical Metallurgy Laboratory .....	1
MSE	470	Polymers and Composites .....	3
MSE	471	Introduction to Ceramics.....	3
MSE	482	Materials Engineering Design.....	3
MSE	490	Capstone Design Project ...	1-3
PHY	361	Introductory Modern Physics.....	3
		Technical electives .....	6

<sup>1</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 277.

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

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

#### Materials Science and Engineering Areas of Emphasis

Technical electives may be selected from one or more of the following areas. A student may, with prior ap-

proval of the department, select a general area or a set of courses that would support a career objective not covered by the following categories.

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

BME	318	Biomaterials .....	3
BME	411	Biomedical Engineering I.....	3
BME	412	Biomedical Engineering II .....	3
BME	413	Biomedical Instrumentation.....	3
BME	416	Biomechanics .....	3
CHM	361	Principles of Biochemistry .....	3
MSE	430	Thermodynamics of Materials.....	3
MSE	431	Corrosion and Corrosion Control.....	3
MSE	440	Mechanical Properties of Solids.....	3
MSE	441	Analysis of Material Failures .....	3
MSE	450	X-Ray and Electron Diffraction .....	3
MSE	471	Introduction to Ceramics.....	3

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

CHM	331	General Organic Chemistry...3	
CHM	332	General Organic Chemistry...3	
CHM	471	Solid State Chemistry.....3	
EEE	435	Microelectronics.....3	
EEE	436	Fundamentals of Solid State Devices .....	3
EEE	439	Semiconductor Facilities and Cleanroom Practices .....	3
MSE	430	Thermodynamics of Materials.....	3
MSE	450	X-Ray and Electron Diffraction .....	3
MSE	453	Experiments in Materials Synthesis and Processing II...2	
MSE	454	Advanced Materials Processing and Synthesis .....	3
MSE	472	Integrated Circuit Materials Science .....	3

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

MAE	441	Principles of Design .....	3
MAE	442	Mechanical Systems Design.....	3
MSE	430	Thermodynamics of Materials.....	3
MSE	431	Corrosion and Corrosion Control.....	3

MSE	440	Mechanical Properties of Solids.....	3
MSE	441	Analysis of Material Failures .....	3
MSE	450	X-Ray and Electron Diffraction .....	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
CHM	471	Solid State Chemistry.....	3
EEE	435	Microelectronics.....	3
EEE	436	Fundamentals of Solid State Devices .....	3
EEE	439	Semiconductor Facilities and Cleanroom Practices.....	3
MSE	430	Thermodynamics of Materials.....	3
MSE	450	X-Ray and Electron Diffraction .....	3
MSE	453	Experiments in Materials Synthesis and Processing II...2	
MSE	454	Advanced Materials Processing and Synthesis .....	3
MSE	471	Introduction to Ceramics.....	3
MSE	472	Integrated Circuit Materials Science .....	3

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

CHE	458	Semiconductor Material Processing.....	3
MAE	422	Mechanics of Materials .....	4
MAE	441	Principles of Design .....	3
MAE	442	Mechanical Systems Design..3	
MSE	430	Thermodynamics of Materials.....	3
MSE	431	Corrosion and Corrosion Control.....	3
MSE	440	Mechanical Properties of Solids.....	3
MSE	441	Analysis of Material Failures .....	3
MSE	450	X-Ray and Electron Diffraction .....	3
MSE	453	Experiments in Materials Synthesis and Processing II...2	
MSE	454	Advanced Materials Processing and Synthesis .....	3
MSE	471	Introduction to Ceramics.....	3
MSE	472	Integrated Circuit Materials Science .....	3

**Mechanical Metallurgy.** Students interested in the materials used in the semiconductor industry and in how they are processed to achieve the desired prop-

erties should choose from the following technical electives:

MAE 415	Vibration Analysis.....	4
MAE 422	Mechanics of Materials .....	4
MAE 441	Principles of Design .....	3
MAE 442	Mechanical Systems Design.....	3
MSE 430	Thermodynamics of Materials.....	3
MSE 431	Corrosion and Corrosion Control.....	3
MSE 440	Mechanical Properties of Solids.....	3
MSE 441	Analysis of Materials Failures .....	3
MSE 450	X-Ray and Electron Diffraction .....	3
MSE 471	Introduction to Ceramics.....	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 Survey.....	3
MSE 430	Thermodynamics of Materials.....	3
MSE 431	Corrosion and Corrosion Control.....	3
MSE 440	Mechanical Properties of Solids.....	3
MSE 441	Analysis of Material Failures .....	3
MSE 450	X-Ray and Electron Diffraction .....	3
MSE 472	Integrated Circuit Materials Science .....	3

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

CHM 331	General Organic Chemistry...	3
CHM 332	General Organic Chemistry...	3
CHM 471	Solid State Chemistry.....	3
MSE 430	Thermodynamics of Materials.....	3
MSE 440	Mechanical Properties of Solids.....	3
MSE 441	Analysis of Material Failures .....	3
MSE 450	X-Ray and Electron Diffraction .....	3
MSE 472	Integrated Circuit Materials Science .....	3

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

**First Semester**

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

**Second Semester**

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

**Second Year**

**First Semester**

ECE 210	Engineering Mechanics I: Statics .....	3
ECE 350	Structure and Properties of Materials .....	3
MAT 242	Elementary Linear Algebra NI .....	2
MAT 274	Elementary Differential Equations.....	3
PHY 131	University Physics II: Electricity and Magnetism S1/S2 <sup>2</sup> .....	3
PHY 132	University Physics Laboratory II S1/S2 <sup>2</sup> .....	1
Total		15

**Second Semester**  
Choose between the three combinations of courses below.....3-4

CHM 341	Elementary Physical Chemistry (3)	
CHM 343	Physical Chemistry Laboratory (1)	
— or —		
CHM 331	General Organic Chemistry (3)	
CHM 335	General Organic Chemistry Laboratory (1)	
— or —		
CHM 471	Solid State Chemistry (3)	
ECE 301	Electrical Networks I.....	4
ECE 313	Introduction to Deformable Solids.....	3
ECE 340	Thermodynamics.....	3
MAT 272	Calculus with Analytic Geometry III.....	4
Total		17-18

**Third Year**

**First Semester**

BME 331	Biomedical Engineering Transport I: Fluids.....	3
ECE 300	Intermediate Engineering Design L1 .....	3
MSE 353	Introduction to Materials Processing and Synthesis .....	3
MSE 355	Introduction to Materials Science and Engineering .....	3
PHY 361	Introductory Modern Physics.....	3
HU, SB, and awareness area courses <sup>3</sup>		3
Total		18

**Second Semester**

ECE 380	Probability and Statistics for Engineering Problem Solving.....	3
ECE 394	ST: Conservation Principles..	4
MSE 354	Experiments in Materials Synthesis and Processing I ....	2
MSE 420	Physical Metallurgy.....	3
MSE 421	Physical Metallurgy Laboratory .....	1
HU, SB, and awareness area courses <sup>3</sup>		3
Total		15

**Fourth Year**

**First Semester**

ECE 400	Engineering Communications L2 .....	3
MSE 470	Polymers and Composites .....	3
MSE 482	Materials Engineering Design.....	3
HU, SB, and awareness area courses <sup>3</sup>		3
Technical elective.....		3
Total		15

**Second Semester**

MSE 471	Introduction to Ceramics.....	3
MSE 490	Capstone Design Project .....	3
HU, SB, and awareness area courses <sup>3</sup>		7
Technical elective.....		3-4
Total		16-17

*Degree requirements: 128 semester hours.*

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

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

<sup>3</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 277.

## CHEMICAL ENGINEERING

### CHE 311 Introduction to Chemical Processing. (3) F, S

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

### 312 Introduction to Thermodynamics. (3) F, S

Energy balance calculations and introduction of thermodynamic principles. Prerequisite: CHE 311.

### 331 Transport Phenomena I: Fluids. (4) F, S *Effective through spring 1997.*

Transport phenomena, with emphasis on fluid systems. Prerequisites: CHE 311; ECE 394 ST: Conservation Principles; MAT 274; PHY 131.

### 331 Transport Phenomena I: Fluids. (3) F, S *Effective starting fall 1997.*

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

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

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

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

The application of transport phenomena to mass transfer. The design of mass transfer equipment, including staged processes. Pre- or corequisites: CHE 332.

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

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

### 352 Transport Laboratories. (3) S *Effective through fall 1996.*

The demonstration of transport phenomena principles with experiments in fluid flow, heat, and mass transfer. Prerequisite: CHE 331. Pre- or corequisite: CHE 332. *General Studies: L1.*

### 352 Transport Laboratories. (3) S *Effective starting spring 1997.*

The demonstration of transport phenomena principles with experiments in fluid flow, heat, and mass transfer. Prerequisite: CHE 332; ECE 300. Pre- or corequisite: CHE 333. *General Studies: L1.*

### 411 Biomedical Engineering I. (3) F

Review of diagnostic and prosthetic methods using engineering methodology. Introduction to transport, metabolic, and autoregulatory processes in the human body. Cross-listed as BME 411. Prerequisite: instructor approval.

### 413 Biomedical Instrumentation I. (3) F

Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems. Prerequisites: AGB/BME 435 (grade of "C" or higher); ECE 334.

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

Multicomponent distillation, engineering economics, equipment sizing and costs, plant op-

eration economics, and simulation and optimization techniques. Prerequisites: CHE 332, 342.

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

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

### 451 Chemical Engineering Laboratory. (2) F

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

### 458 Semiconductor Material Processing. (3) N

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

### 461 Process Control. (4) F

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

### 462 Process Design. (3) S

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

### 475 Biochemical Engineering. (3) N

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

### 476 Bioreaction Engineering. (3) N

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

### 477 Bioseparation Processes. (3) N

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

### 490 Chemical Engineering Projects. (1-5) F, S, SS

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

### 496 Professional Seminar. (1-3) F, S

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

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

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

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

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

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

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

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

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

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

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

### 518 Introduction to Biomaterials. (3) F

Topics include structure property relationships for synthetic and natural biomaterials, biocompatibility, and uses of materials to replace body parts. Cross-listed as BME 518. Prerequisite: ECE 313 or instructor approval.

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

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

### 528 Process Optimization Techniques. (3) S

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

### 533 Transport Processes I. (3) F

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

### 534 Transport Processes II. (3) S

Continuation of CHE/BME 533, emphasizing mass transfer. Cross-listed as BME 534. Prerequisite: BME/CHE 533.

### 536 Convective Mass Transfer. (3) N

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

### 543 Thermodynamics of Chemical Systems. (3) F

Classical and statistical thermodynamics of nonideal physicochemical systems and processes; prediction of optimum operating conditions. Cross-listed as BME 543.

### 544 Chemical Reactor Engineering. (3) S

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

### 548 Topics in Catalysis. (3) N

Engineering catalysis, emphasizing adsorption, kinetics, characterization, diffusional considerations, and reactor design. Other topics include mechanisms, surface analyses, and electronic structure.

### 552 Industrial Water Quality Engineering. (3) N

Water pollutants, quality criteria and control, chemical treatment processing, and system design. Case studies. Prerequisite: CHE 331 or equivalent.

### 553 Air Quality Control. (3) N

Air pollutant origins, effects, and control. Physical and chemical processes, including dispersion, combustion, sampling, control equipment design, and special topics. Prerequisite: CHE 331 or equivalent.

### 554 New Energy Technology. (3) N

Gasification, liquefaction pyrolysis, and combustion processes for coal, wastes, and other raw materials. In-situ processes for coal, oil, shale, and geothermal energy. Environmental quality issues.

**556 Separation Processes.** (3) N

Topics in binary/multicomponent separation, rate governed and equilibration processes, mass transfer criteria, energy requirements, separating agents and devices, and staged operations.

**558 Electronic Materials.** (3) N

Processing and characterization of electronic materials for semiconductor type uses. Thermodynamics and transport phenomena, phase equilibria and structure, mass transfer, and diffusion and thermal properties.

**561 Advanced Process Control.** (3) S

Dynamic process representation, linear optimal control, optimal state reconstruction, and parameter and state estimation techniques for continuous and discrete time systems.

**563 Chemical Engineering Design.** (3) N

Computational methods; the design of chemical plants and processes.

**BIOENGINEERING****BME 201 Introduction to Bioengineering.**

(3) F

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

**202 Global Awareness within Biomedical Engineering Design.** (3) F

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

**318 Biomaterials.** (3) S

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

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

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

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

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

**411 Biomedical Engineering I.** (3) F

Review of diagnostic and prosthetic methods using engineering methodology. Introduction to transport, metabolic, and autoregulatory processes in the human body. Cross-listed as CHE 411. Prerequisite: instructor approval.

**412 Biomedical Engineering II.** (3) S

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

**413 Biomedical Instrumentation.** (3) F

Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic

variables in living systems. Prerequisites:

BME 435 (grade of "C" or higher); ECE 300, 334. Corequisite: BME 423. *General Studies: L2.*

**414 Biomedical Instrumentation II.** (3) N

Principles of applied biophysical measurements using bioelectric and radiological approaches. Prerequisite: BME 413 and ECE 334, MAT 274 or instructor approval.

**414 Biomedical Measurements.** (3) N*Effective starting spring 1997*

Principles of applied biophysical measurements using bioelectric and radiological approaches. Prerequisite: instructor approval.

**415 Biomedical Transport Processes.** (3) A

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

**416 Biomechanics.** (3) F

Mechanical properties of bone, muscle, and soft tissues. Static and dynamic analysis of human movement tasks such as locomotion. Prerequisite: BME 318.

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

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

**419 Biocontrol Systems.** (3) S

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

**423 Biomedical Instrumentation Laboratory.** (1) F

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

**435 Physiology for Engineers.** (4) F

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

**461 Health Physics Principles and Radiation Measurements.** (3) S

Sources, characteristics, dosimetry, shielding, and measurement techniques for cosmogenic, terrestrial, and anthropogenic radiation. Ionizing and nonionizing radiation theory. ALARA concept. Emphasis on instrumentation, detectors, and environmental monitoring. Lecture, lab. Prerequisite: ECE 301.

**465 Clinical Nuclear Engineering I.** (3) N

Fundamentals of clinical nuclear engineering and medical health physics practice. Radiation biology, dosimetry, and shielding for radiotherapy and diagnostic procedures. Prerequisite: instructor approval.

**470 Microcomputer Applications in Bioengineering.** (4) S*Effective through fall 1996.*

Use of microcomputers for real-time data col-

lection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Prerequisites: BME 435; CSE 181 or basic programming experience; ECE 334.

**470 Microcomputer Applications in Bioengineering.** (4) S*Effective starting spring 1997.*

Use of microcomputers for real-time data collection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Prerequisites: BME 435; ECE 100, 334.

**490 Biomedical Engineering Projects.** (1–5) F, S, SS*Effective through fall 1996.*

Individual projects in medical systems or medical device design and development.

**490 Biomedical Engineering Capstone Design II.** (1–4) F, S, SS*Effective starting spring 1997.*

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

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

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

**511 Biomedical Engineering.** (3) A

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

**512 Biomedical Engineering II.** (3) A

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

**513 Biomedical Instrumentation I.** (3) A

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

**514 Advanced Biomedical Instrumentation.** (3) F

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

**515 Biomedical Transport Processes.** (3) N

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

**516 Topics in Biomechanics.** (3) S

Mechanical properties of bone, muscle, and soft tissues. Static and dynamic analysis of human movement tasks, including in-depth project. Prerequisites: ECE 312 and 313 or instructor approval.

**517 Medical Transport Devices I.** (3) N

Heat, mass, and momentum transfer concepts are developed from first principles and applied to the design and application of medical devices. Emphasis is an extracorporeal treatment of blood with channel dimensions which greatly exceed cellular dimensions. Cross-listed as CHE 517. Prerequisites: partial differential equations; at least 1 course in heat, mass, or momentum transfer.

**518 Introduction to Biomaterials.** (3) F  
Topics include structure property relationships for synthetic and natural biomaterials, biocompatibility, and uses of materials to replace body parts. Cross-listed as CHE 518. Prerequisite: ECE 313 or instructor approval.

**519 Topics in Biocontrol Systems.** (3) F  
Linear and nonlinear control systems analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body, including in-depth project. Prerequisite: MAT 274.

**520 Bioelectric Phenomena.** (3) N  
Study of the origin, propagation, and interactions of bioelectricity in living things; volume conductor problem, mathematical analysis of bioelectric interactions, and uses in medical diagnostics.

**521 Neuromuscular Control Systems.** (3) S  
Overview of sensorimotor brain structures. Application of nonlinear, adaptive, optimal, and supervisory control theory to eye-head-hand coordination and locomotion.

**522 Biosensor Design and Application.** (3) A  
Theory and principles of biosensor design and application in medicine and biology. Principles of measurements with biosensors. Prerequisite: instructor approval.

**523 Physiological Instrumentation Lab.** (1) F  
Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Pre- or corequisites: AGB/BME 435; BME/CHE 413; ECE 334.

**524 Fundamentals of Applied Neural Control.** (3) A  
Fundamental concepts of electrical stimulation and recording in the nervous system with the goal of functional control restoration. Pre- or corequisite: BME 435 or instructor approval.

**525 Surgical Techniques.** (2) S  
Principles of surgical techniques, standard operative procedures, federal regulations, guidelines, and state-of-the-art methods. Lecture, lab.

**532 Prosthetic and Rehabilitation Engineering.** (3) A  
Analysis and critical assessment of design and control strategies for state-of-the-art medical devices used in rehabilitation engineering. Pre- or corequisites: BME 416 (or EPE 610), 419, 435; ECE 312, 313.

**533 Transport Processes I.** (3) F  
Unified treatment of momentum, heat, and mass transfer from molecular theory, and continuum points of view. Continuum equations of microscopic and macroscopic systems and multicomponent and multiphase systems. Cross-listed as CHE 533.

**534 Transport Processes II.** (3) S  
Continuation of BME/CHE 533, emphasizing mass transfer. Cross-listed as CHE 534. Prerequisite: BME/CHE 533.

**543 Thermodynamics of Chemical Systems.** (3) F  
Classical and statistical thermodynamics of nonideal physicochemical systems and processes; prediction of optimum operating conditions. Cross-listed as CHE 543.

**544 Chemical Reactor Engineering.** (3) S  
Reaction rates, thermodynamics, and transport principles applied to the design and operation of chemical reactors. Cross-listed as CHE 544. Prerequisite: BME/CHE 543.

**551 Movement Biomechanics.** (3) S  
Mechanics applied to the analysis and modeling of physiological movements. Computational modeling of muscles, tendons, joints, and the skeletal system with application to sports and rehabilitation. Prerequisite: BME 416 or instructor approval.

**566 Medical Imaging Instrumentation.** (3) N  
Design and analysis of imaging systems and nuclear devices for medical diagnosis, therapy, and research. Laboratory experiments using diagnostic radiology, fluoroscopy, ultrasound, and CAT scanning. Lecture, lab. Prerequisite: BME 465 or EEE 465 or instructor approval.

**568 Medical Tomography.** (3) S  
CT, SPECT, PET, and MRI. 3-dimensional *in vivo* measurements. Instrument design, physiological modeling, clinical protocols, reconstruction algorithms, and quantitation issues. Prerequisite: EEE 465.

**569 Radiochemistry and Radiopharmaceutical Production.** (3) N  
Advanced principles of cyclotron design, targetry, operation, and utilization. Novel synthesis, tracer preparation, quality control, and biodistribution studies. Prerequisite: BME 465 or EEE 465.

## MATERIALS SCIENCE AND ENGINEERING

**MSE 353 Introduction to Materials Processing and Synthesis.** (3) F  
Principles of materials structure and properties with emphasis on applications in bulk and thin film materials processing and synthesis. Cross-listed as EEE 353. Prerequisites: CHM 116; PHY 131; or equivalents.

**354 Experiments in Materials Synthesis and Processing I.** (2) S  
Small groups of students complete three experiments selected from a list. Each is supervised by a selected faculty member. Lab. Cross-listed as EEE 354. Prerequisite: EEE/MSE 353 or equivalent.

**355 Introduction to Materials Science and Engineering.** (3) F  
Elements of the structure of metals and alloys, measurement of mechanical properties, and optical metallography. Lecture, lab, field trips. Prerequisite: CHM 114 or 116.

**420 Physical Metallurgy.** (3) F  
Crystal structure and defects. Phase diagrams, metallography, solidification and casting, deformation, and annealing. Prerequisite: ECE 350.

**421 Physical Metallurgy Laboratory.** (1) S  
Focuses on analysis of microstructure of metals and alloys and includes correlation with mechanical properties to some extent. Lab. Pre- or corequisite: MSE 420.

**430 Thermodynamics of Materials.** (3) N  
Principles of statistical mechanics, statistical thermodynamics of single crystals, solutions, phase equilibrium, free energy of reactions, free electron theory, and thermodynamics of defects. Prerequisite: ECE 340.

**431 Corrosion and Corrosion Control.** (3) S  
Introduction to corrosion mechanisms and methods of preventing corrosion. Topics in-

clude the following: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: ECE 350.

**440 Mechanical Properties of Solids.** (3) S  
Effects of environmental and microstructural variables of mechanical properties, including plastic deformation, fatigue, creep, brittle fracture, and internal friction. Prerequisite: ECE 350.

**441 Analysis of Material Failures.** (3) S  
Identification of types of failures. Analytical techniques. Fractography, SEM, nondestructive inspection, and metallography. Mechanical and electronic components. Prerequisite: ECE 350.

**450 X-Ray and Electron Diffraction.** (3) F  
Fundamentals of X-ray diffraction, transmission electron microscopy, and scanning electron microscopy. Techniques for studying surfaces, internal microstructures, and fluorescence. Lecture, demonstrations. Prerequisite: ECE 350.

**453 Experiments in Materials Synthesis and Processing II.** (2) F  
A continuation of MSE 354, with emphasis on characterization. Small groups complete three experiments supervised by selected faculty members. Lab. Cross-listed as EEE 453. Prerequisites: EEE/MSE 353 and 354 or equivalents.

**454 Advanced Materials Processing and Synthesis.** (3) S  
Case studies from published literature of current techniques in materials processing and synthesis. Student participation in classroom presentations. Lecture, recitation. Cross-listed as EEE 454. Prerequisites: EEE/MSE 353 and 354 or equivalents.

**470 Polymers and Composites.** (3) F  
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MAE 455. Prerequisite: ECE 350.

**471 Introduction to Ceramics.** (3) F  
Principles of structure and property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: ECE 350.

**472 Integrated Circuit Materials Science.** (3) N  
Principles of materials science applied to semiconductor processing and fabrication in metals, ceramics, polymers, and semiconductors. Prerequisite: ECE 350.

**476 Nonmetallic Materials Laboratory.** (2) S  
Experimental measurement of properties of polymeric, ceramic, and electronic materials. Structure characterization. Lecture, lab. Prerequisites: ECE 350; MSE 355.

**482 Materials Engineering Design.** (3) F, S  
Principles of the design process. Feasibility and optimization. Manufacturing processes, materials selection, failure analysis, and economics. Prerequisites: ECE 313, 350.

**490 Capstone Design Project.** (1–3) F, S  
For small groups in fundamental or applied aspects of engineering materials; emphasis on experimental problems and design. Prerequisites: MSE 430, 440, 450.

**496 Professional Seminar.** (1–3) F, S  
Professional and ethical aspects with a discussion of responsibilities. Lectures, field trips. Prerequisite: instructor approval.

**510 X-Ray and Electron Diffraction.** (3) F Fundamentals of X-ray diffraction, transmission electron microscopy, and scanning electron microscopy. Techniques for studying surfaces, internal microstructures, and fluorescence. Lecture, demonstrations. Prerequisite: transition student with instructor approval.

**511 Corrosion and Corrosion Control.** (3) S Introduction to corrosion mechanisms and methods of preventing corrosion. Topics include the following: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: transition student with instructor approval.

**512 Analysis of Material Failures.** (3) S Identification of types of failures. Analytical techniques. Fractography, SEM, nondestructive inspection, and metallography. Mechanical and electronic components. Prerequisite: transition student with instructor approval.

**513 Polymers and Composites.** (3) F Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems.

**514 Physical Metallurgy.** (4) F Crystal structure and defects. Phase diagrams, metallography, solidification and casting, and deformation and annealing. Lecture, lab. Prerequisite: transition student with instructor approval.

**515 Thermodynamics of Materials.** (3) N Principles of statistical mechanics, statistical thermodynamics of single crystals, solutions, phase equilibrium, free energy of reactions, free electron theory, and thermodynamics of defects. Prerequisite: transition student with instructor approval.

**516 Mechanical Properties of Solids.** (3) S Effects of environmental and microstructural variables of mechanical properties, including plastic deformation, fatigue, creep, brittle fracture, and internal friction. Prerequisite: transition student with instructor approval.

**517 Introduction to Ceramics.** (3) F Principles of structure, property relations in ceramic materials. Processing techniques. Applications in mechanical, electronic, and superconducting systems. Prerequisite: transition student with instructor approval.

**518 Integrated Circuits Materials Science.** (3) N Principles of materials science applied to semiconductor processing and fabrication in metals, ceramics, polymers, and semiconductors. Prerequisite: transition student with instructor approval.

**520 Theory of Crystalline Solids.** (3) F Anisotropic properties of crystals; tensor treatment of elastic, magnetic, electric and thermal properties, and crystallography of Martensitic transformations.

**521 Defects in Crystalline Solids.** (3) S Introduction to the geometry, interaction, and equilibrium between dislocations and point defects. Relations between defects and properties will be discussed. Prerequisite: ECE 350 or instructor approval.

**530 Materials Thermodynamics and Kinetics.** (3) S Thermodynamics of alloy systems, diffusion in solids, kinetics of precipitation, and phase

transformations in solids. Prerequisites: CHE 312 or ECE 340; ECE 350.

**531 Statistical Thermodynamics.** (3) N Kinetic and quantum theory. Statistical mechanics; ensemble theory. Structure and thermodynamics of non-interacting and interacting particles. Boltzmann integro-differential equation. Cross-listed as MAE 582. Prerequisite: MAE 581.

**533 Direct Energy Conversion.** (3) N Advanced selected topics in direct energy conversion, theory, design, and applications. Prerequisite: MAE 581.

**540 Fracture, Fatigue, and Creep.** (3) F Relationship between microstructure and fracture; fatigue and creep properties of materials. Environmental effects and recent developments. Current theories and experimental results. Prerequisite: MSE 440 or equivalent.

**550 Advanced Materials Characterization.** (3) N Analytical instrumentation for characterization of materials; SEM, SIMS, Auger, analytical TEM, and other advanced research techniques.

**556 Electron Microscopy Laboratory.** (3) F Lab support for MSE 558. Cross-listed as SEM 556. Pre- or corequisite: MSE/SEM 558.

**557 Electron Microscopy Laboratory.** (3) S Lab support for MSE 559. Cross-listed as SEM 557. Pre- or corequisite: MSE/SEM 559.

**558 Electron Microscopy I.** (3) F Microanalysis of the structure and composition of materials using images, diffraction and X-ray, and energy loss spectroscopy. Knowledge of elementary crystallography, reciprocal lattice, stereographic projections, and complex variables is required. Cross-listed as SEM 558. Prerequisite: instructor approval.

**559 Electron Microscopy II.** (3) S Microanalysis of the structure and composition of materials using images, diffraction and X-ray, and energy loss spectroscopy. Knowledge of elementary crystallography, reciprocal lattice, stereographic projections, and complex variables is required. Cross-listed as SEM 559. Prerequisite: instructor approval.

**560 Strengthening Mechanisms.** (3) S Deformation of crystalline materials. Properties of dislocations. Theories of strain hardening, solid solution, precipitation, and transformation strengthening. Prerequisite: ECE 350 or equivalent.

**561 Phase Transformation in Solids.** (3) N Heterogeneous and homogeneous precipitation reactions, shear displacive reactions, and order-disorder transformation.

**562 Ion Implantation.** (3) S Includes defect production and annealing. Generalized treatment, including ion implantation, neutron irradiation damage, and the interaction of other incident beams. Prerequisite: MSE 450.

**570 Polymer Structure and Properties.** (3) F Relationships between structure and properties of synthetic polymers, including glass transition, molecular relaxations, crystalline state viscoelasticity, morphological characterization, and processing.

**571 Ceramics.** (3) A Includes ceramic processing, casting, molding, firing, sintering, crystal defects, and mechanical, electronic, and physical properties. Prerequisites: MSE 521, 561.

**572 Semiconductor Phase Diagrams.** (3) A Analysis of binary and ternary phase diagrams and application to semiconductor growth and vapor and liquid phase epitaxy. Prerequisite: MSE 521.

**573 Magnetic Materials.** (3) A Emphasis on ferromagnetic and ferrimagnetic phenomena. Domains, magnetic anisotropy, and magnetostriction. Study of commercial magnetic materials. Prerequisite: MSE 520 or equivalent.

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## Department of Civil and Environmental Engineering

Larry W. Mays  
Chair  
(ECG 252) 602/965-3589

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### PROFESSORS

S. HOUSTON, W. HOUSTON,  
MAMLOUK, MATTHIAS, MAYS,  
O'BANNON, SINGHAL, UPCHURCH

### ASSOCIATE PROFESSORS

DUFFY, FAFITIS, HINKS, JOHNSON,  
RAJAN, ZANIEWSKI

### ASSISTANT PROFESSORS

BAKER, FOX,  
MOBASHER, WESTERHOFF

### PROFESSORS EMERITI

BETZ, BLACKBURN, BORGIO,  
KLOCK, LUNDGREN, PIAN, RUFF

### CIVIL ENGINEERING

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

### Career opportunities in the field.

University graduates with the B.S.E. in Civil Engineering degree 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 at ASU offers a challenging program of study designed to provide the student with the resources and background to pursue a career in a wide range of specialty areas. Some of these areas are structural, geotechnical, environmental and water resources, transportation and materials engineering. The Civil Engineering program is fully accredited by ABET. With the program, students will be prepared for the Fundamentals of Engineering (FE) examination and professional registration.

The Department of Civil and Environmental Engineering offers challenging programs of study designed to provide students with the scientific and technical resources to pursue a broad and multifaceted range of careers. Areas of study in the civil engineering curriculum are described below.

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

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

*Transportation and materials engineering.* This area of study is pursued in two major areas and several interrelated areas: (1) transportation planning, design, and operation, and (2) pavements and materials. Transportation planning, design, and operation emphasizes the

highway mode but also encompasses public transit and airport planning and design. Urban transport planning, geometric design of facilities, traffic operations, and evaluation of highway capacity and safety are also a part of transportation planning. The application of advanced technology to the vehicle and the roadway is included in the study of intelligent vehicle/highway systems. Pavements and materials focus on pavement analysis and design, pavement maintenance and rehabilitation, pavement evaluation and management, and characterization of highway materials such as asphalt, concrete, portland cement, and portland cement concrete; durability of highway structures; and structural retro-fit of existing bridges.

*Water resources engineering.* This area of study is concerned with surface and groundwater flow; planning and management of water supply; water distribution system modeling.

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

### Environmental Engineering Option

A new Environmental Engineering option has been developed and recently implemented at ASU. Environmental engineering is a multidisciplinary field based on the traditional engineering principles; and chemistry, biology, and geology. Environmental engineers are involved with the design and operation of water and wastewater treatment systems, remediation of contaminated soils and waters, construction of hazardous waste containment systems, analysis of the fate and transport of pollutants in natural environments, water conservation and reuse, and surface water quality management.

### Career opportunities in the field.

University graduates with the B.S.E. in Civil Engineering (Environmental Engineering option) find employment in consulting firms, municipalities, regulatory agencies, and industry. The growth of environmental engineering positions has been balanced by the growing number of students entering the field, resulting in a stable job market. International opportunities are great and are likely to expand. Entry level salaries typically range from \$30,000 to \$50,000 and more, depending upon their responsibilities. After

earning the undergraduate B.S.E. in Civil Engineering degree (Environmental Engineering option), many students continue their education by enrolling in an environmental engineering graduate degree program.

### Uniqueness of the program at ASU.

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

### ENTRANCE REQUIREMENTS

See "Admission," and "Degrees and Majors," pages 276–277 for information regarding entrance requirements.

### DEGREE REQUIREMENTS

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

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

#### Civil Engineering

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

#### Environmental Engineering Option

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

### Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

**Course Requirements.** See pages 277–278 for General Studies, school, and engineering core requirements.

**Civil Engineering Core**

Twenty-three hours are required. CEE courses, except CEE 296, may not be taken until all mathematics (MAT) and all engineering core courses (ECE), except ECE 380 and 384 have been completed with an average grade of "C" or better. No CEE 400-level courses may be taken until ECE 380 and 384 have been completed.

CEE 296	Civil Engineering Systems	....3
CEE 321	Structural Analysis and Design	.....4
CEE 341	Fluid Mechanics for Civil Engineers	.....4
CEE 351	Geotechnical Engineering	....4
CEE 361	Introduction to Environmental Engineering	...4
CEE 372	Transportation Engineering	...4
CEE 496	Topics in Civil Engineering Practice	.....1
ECE 380	Probability and Statistics for Engineering Problem Solving	.....3

**Civil Engineering Design Electives**

CEE 486 plus two courses (six semester hours) from the following list are required for a total of nine semester hours.

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

**Civil Engineering Technical Electives**

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

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

**Construction**

CON 341	Surveying	.....3
CON 383	Construction Estimating	.....3
CON 495	Construction Planning and Scheduling N3	.....3
CON 496	Construction Contract Administration	.....3

**Environmental Engineering**

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

CEE 466	Sanitary Systems Design	.....3
CHM 231	Elementary Organic Chemistry S1/S2 <sup>1</sup>	.....3
MIC 220	Biology of Microorganisms or MIC 205 Microbiology S2 <sup>2</sup> (3) and MIC 206 Microbiology Laboratory S2 <sup>2</sup> (1)	.....3

**Geotechnical Engineering**

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

CEE 452	Foundations	.....3
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**Structural Engineering**

This area includes analysis and design of structures for buildings, bridges, space frames, structural mechanics.

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

**Transportation/Materials Engineering**

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

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

**Water Resources Engineering**

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

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

<sup>1</sup> Both CHM 231 and 235 must be taken to secure S1 or S2 credit.

<sup>2</sup> Both MIC 205 and 206 must be taken to secure S2 credit.

**Civil Engineering Program of Study A Four-Year Sequence Freshman Year**

**First Semester**

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

**Second Semester**

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

**Sophomore Year**

**First Semester**

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

**Second Semester**

ECE 301	Electrical Networks I or ECE 340 Thermodynamics (3)	.....4
ECE 312	Engineering Mechanics II: Dynamics	.....3
ECE 313	Introduction to Deformable Solids	.....3
ECE 384	Numerical Analysis for Engineers I	.....2
ECN 111	Macroeconomic Principles SB or ECN 112 Microeconomic Principles SB (3)	.....3
Basic science elective		.....3
Total		.....17-18

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71-94. For graduation requirements, see pages 66-70. Omnibus courses are offered that are not listed in the catalog; see pages 44-45.

**Junior Year****First Semester**

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

**Second Semester**

CEE 351	Geotechnical Engineering .....	4
CEE 361	Introduction to Environmental Engineering .....	4
CEE 372	Transportation Engineering...4	
HU, SB, and awareness area courses <sup>3</sup>	.....	3
Total	.....	15

**Senior Year****First Semester**

CEE 496	Topics in Civil Engineering Practice .....	1
Design elective	.....	3
HU, SB, and awareness area courses <sup>3</sup>	.....	4
Technical electives	.....	9
Total	.....	17

**Second Semester**

CEE 486	Integrated Civil Engineering Design <i>L2</i> .....	3
Design elective	.....	3
HU, SB, and awareness area courses <sup>3</sup>	.....	3
Technical electives	.....	6-7
Total	.....	15-16

*Graduation requirements: 128 semester hours.*

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

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

<sup>3</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 277.

Students are required to have an average grade of "C" or better in design and technical electives totaling 22-23 semester hours. Two graduate courses may be taken for undergraduate credit by students whose cumulative GPA is 3.00 or better and with the approval of the instructor, advisor, department chair, and the dean of the college.

**Concurrent Studies in Architecture and Civil Engineering**

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

**DEGREE REQUIREMENTS FOR ENVIRONMENTAL ENGINEERING OPTION****Environmental Engineering Core**

See pages 277-278 for General Studies, school, and engineering core requirements.

Twenty-four semester hours are required. CEE courses, except CEE 296, may not be taken until all chemistry (CHM), mathematics (MAT), physics (PHY), and engineering core (ECE) courses, except ECE 380 and 384, have been completed with an average grade of "C" or better. No CEE 400-level courses may be taken until ECE 380 and 384 have been completed.

CEE 296	Civil Engineering Systems .....	3
CEE 321	Structural Analysis and Design.....	4
CEE 341	Fluid Mechanics for Civil Engineers.....	4
CEE 351	Geotechnical Engineering .....	4
CEE 361	Introduction to Environmental Engineering...4	
CEE 372	Transportation Engineering...4	
CEE 496	Topics in Civil Engineering Practice .....	1
CHM 341	Elementary Physical Chemistry .....	3
ECE 380	Probability and Statistics for Engineering Problem Solving .....	3

**Environmental Design Courses**

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

**Environmental Technical Courses**

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

\*Both MIC 205 and 206 must be taken to secure S2 credit.

**Environmental Engineering Program of Study A Four-Year Sequence Freshman Year****First Semester**

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

**Second Semester**

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

**Sophomore Year****First Semester**

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

**Second Semester**

CHM 231	Elementary Organic Chemistry <i>S1/S2</i> <sup>4</sup> .....	3
ECE 312	Engineering Mechanics II: Dynamics.....	3
ECE 313	Introduction to Deformable Solids.....	3
ECE 340	Thermodynamics.....	3
ECE 384	Numerical Analysis for Engineers I.....	2
ECN 111	Macroeconomic Principles <i>SB</i> .....	3
or ECN 112	Microeconomic Principles <i>SB</i> (3)	
Total	.....	17

**Junior Year****First Semester**

CEE 321	Structural Analysis and Design.....	4
CEE 341	Fluid Mechanics for Civil Engineers.....	4
ECE 300	Intermediate Engineering Design <i>L1</i> .....	3
ECE 351	Engineering Materials .....	3

ECE 380	Probability and Statistics for Engineering Problem Solving .....	3
Total .....		17

**Second Semester**

CEE 351	Geotechnical Engineering .....	4
CEE 361	Introduction to Environ- mental Engineering .....	4
CEE 372	Transportation Engineering.....	4
CHM 341	Physical Chemistry.....	3
HU, SB, and awareness area courses <sup>3</sup> .....		3
Total .....		18

**Senior Year**

**First Semester**

CEE 362	Environmental Engineering.....	3
CEE 440	Engineering Hydrology .....	3
CEE 466	Sanitary Systems Design.....	3
CEE 496	Topics in Civil Engineering Practice .....	1
MIC 205	Microbiology S2 <sup>5</sup> .....	3
MIC 206	Microbiology Laboratory S2 <sup>5</sup> .....	1
HU, SB, and awareness area courses <sup>3</sup> .....		4
Total .....		18

**Second Semester**

BIO 320	Fundamentals of Ecology.....	3
	or CHM 302 Environmental Chemistry (3) or CHM 361 Principles of Biochemistry (3) or PUP 475 Environmental Impact Assessment (3)	
CEE 441	Water Resources Engineering .....	3
CEE 486	Integrated Civil Engineering Design L2.....	3
HU, SB, and awareness area courses <sup>3</sup> .....		3
Total .....		12

*Graduation requirements: 128 semester hours.*

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

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

<sup>3</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 277.

<sup>4</sup> Both CHM 231 and 235 must be taken to secure S1 or S2 credit.

<sup>5</sup> Both MIC 205 and 206 must be taken to secure S2 credit.

Students are required to have an average grade of “C” or better in design and technical courses totaling 24 semester hours. Two graduate courses may be taken for undergraduate credit

by students whose cumulative GPA is 3.00 or better and with the approval of the instructor, advisor, department chair, and the dean of the college.

**CIVIL ENGINEERING**

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

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

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

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

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

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

**322 Steel Structures.** (3) F

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

**323 Concrete Structures.** (3) S

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.

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

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

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

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

**351 Geotechnical Engineering.** (4) F, S

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

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

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

**362 Environmental Engineering.** (3) S  
Natural environment, the carbon cycle and biochemistry of wastes, principles of waste treatment, and drainage systems. Prerequisite: CEE 361.

**371 Introduction to Urban Planning.** (3) N  
Theoretical and practical aspects of city planning. Interrelationships among physical planning, environment, government, and society. Not acceptable as a technical elective for CEE students.

**372 Transportation Engineering.** (4) F, S  
Highway, rail, water, and air transportation. Operational characteristics and traffic control devices of each transport mode. Impact on urban form. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

**412 Pavement Analysis and Design.** (3) F  
Design of flexible and rigid pavements for highways and airports. Surface, base, and subgrade courses. Cost analysis and pavement selection. Prerequisites: CEE 351; ECE 351.

**423 Structural Design.** (3) F  
Analysis and design of reinforced concrete steel, masonry, and timber structures. Lecture, lab. Prerequisite: CEE 323. Corequisite: CEE 322.

**432 Matrix and Computer Applications in Structural Engineering.** (3) S  
Matrix and computer applications to structural engineering and structural mechanics. Stiffness and flexibility methods, finite elements, and differences. Prerequisite: CEE 321.

**440 Engineering Hydrology.** (3) F  
Descriptive hydrology; hydrologic cycle, systems, and models. Rain-runoff models. Hydrologic design. Concepts, properties, and basic equations of groundwater flow. Prerequisites: CEE 341; ECE 380.

**441 Water Resources Engineering.** (3) S  
Application of the principles of hydraulics and hydrology to the engineering of water resources projects; design and operation of water resources systems; water quality. Prerequisite: CEE 341.

**450 Soil Mechanics in Construction.** (3) F, S  
Soil mechanics as applied to the construction field, including foundations, highways, retaining walls, and slope stability. Relationship between soil characteristics and geologic formations. Not open to engineering students. Lecture, lab. Prerequisite: CON 323.

**452 Foundations.** (3) F, S  
Applications of soil mechanics to foundation systems, bearing capacity, lateral earth pressure, and slope stability. Prerequisite: CEE 351.

**466 Sanitary Systems Design.** (3) F  
Capacity, planning and design of water supply, domestic and storm drainage, and solid waste systems. Prerequisite: CEE 361.

**471 Intelligent Transportation Systems.** (3) F

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

**475 Highway Geometric Design.** (3) F  
Design of the visible elements of the roadway. Fundamental design controls with application to rural roads, at-grade intersections, free-ways, and interchanges. Lecture, recitation. Prerequisite: CEE 372.

**486 Integrated Civil Engineering Design.** (3) S  
Students are required to complete a civil engineering design in a simulated practicing engineering environment. Lecture, team learning. Limited to undergraduates in their final semester. Prerequisites: CEE 321, 341, 351, 361, 372. *General Studies: L2.*

**496 Topics in Civil Engineering Practice.** (1) F, S  
Professional engineering practice. Interviewing and résumé writing, professional registration requirements, continuing education, graduate study, financial planning, and employment. Prerequisite: senior standing.

**512 Pavement Performance and Management.** (3) F  
Pavement management systems, including data collection, evaluation, optimization, economic analysis, and computer applications for highway and airport design. Prerequisite: CEE 412.

**514 Bituminous Materials and Mixture.** (3) F  
Types of bituminous materials used in pavement mixtures. Chemical composition and physical properties, desirable aggregate characteristics, and optimum asphalt contents. Lecture, lab. Prerequisite: ECE 351.

**515 Properties of Concrete.** (3) S  
Materials science of concrete. Cement chemistry, mechanisms of hydration, interrelationships among micro and macro properties of cement-based materials. Mechanical properties, failure theories, fracture mechanics of concrete materials. Cement-based composite materials and the durability aspects. Lecture, lab. Prerequisite: ECE 350 or 351.

**521 Stress Analysis.** (3) F  
Advanced topics in the analytical determination of stress and strain. Prerequisite: CEE 321.

**524 Advanced Steel Structures.** (3) F  
Strength properties of steel and their effects on structural behavior. Elastic design of steel structures. Plastic analysis and design of beams, frames, and bents. Plastic deflections. Plastic design requirements. Multistory buildings. Prerequisite: CEE 322.

**526 Finite Element Methods in Civil Engineering.** (3) F  
Finite element formulation for solutions of structural, geotechnical, and hydraulic problems. Prerequisite: CEE 432.

**527 Advanced Concrete Structures.** (3) N  
Ultimate strength design. Combined shear and torsion. Serviceability. Plastic analysis. Special systems. Prerequisite: CEE 323.

**528 Stability of Structures.** (3) N  
Elastic and inelastic buckling of rolled and cold-formed columns and beams. Stability of plates, rigid frames, and trusses. Prerequisites: CEE 322; instructor approval.

**529 Complex Structures.** (3) N  
Classical and numerical investigations of linear and nonlinear structures composed of flat and curved surfaces and linear or curvilinear elements. Prerequisite: instructor approval.

**530 Prestressed Concrete.** (3) F '97  
Materials and methods of prestressing. Analysis and design for flexure, shear, and torsion. Prestress losses due to friction, creep, shrinkage, and anchorage set. Statically indeterminate structures. Design of flat slabs, bridges, and composite beams. Prerequisite: CEE 323.

**531 Theory of Structures.** (3) N  
General theorems relating to elastic systems; deflection of trusses and beams; statically indeterminate trusses, beams, rings, arches, and frames by consistent deformation, least work, and elastic center; horizontally curved members in bending and torsion. Prerequisite: CEE 321.

**533 Applied Optimal Design.** (3) S '97  
Linear and nonlinear programming. Problem formulation. Design sensitivity analysis. FEM-based optimal design of structural and mechanical systems. Prerequisite: instructor approval.

**536 Structural Dynamics.** (3) F  
Structures and structural members subjected to dynamic loadings, response spectra theory applications to bridges and power plants, investigations of the responses of multidegree of freedom structures, and matrix and numerical methods of analysis. Lecture, recitation. Prerequisites: CEE 321; instructor approval.

**537 Topics in Structural Engineering.** (1–3) F, S  
Advanced topics, including, wind engineering, earthquake engineering, probabilistic concepts, and bridge and building engineering. Prerequisite: instructor approval.

**540 Groundwater Hydrology.** (3) F  
Physical properties of aquifers, well pumping, subsurface flow modeling, unsaturated flow, numerical methods, land subsidence, and groundwater pollution. Prerequisite: CEE 440 or instructor approval.

**541 Surface Water Hydrology.** (3) S  
Hydrologic cycle and mechanisms, including precipitation, evaporation, and transpiration; hydrograph analysis; flood routing; statistical methods in hydrology and hydrologic design. Prerequisite: CEE 440 or instructor approval.

**542 Water Resources Systems Planning.** (3) A  
Philosophy of water resources planning; economic, social, and engineering interaction; introduction to the theory and application of quantitative planning methodologies in water resources planning. Guest lecturers, case studies. Prerequisite: instructor approval.

**543 Water Resources Systems I.** (3) A  
Theory and application of quantitative planning methodologies for the design and operation of water resources systems; class projects using a computer; case studies. Pre- or corequisite: CEE 542 or instructor approval.

**545 Foundations of Hydraulic Engineering.** (3) S '97  
Review of incompressible fluid dynamics. Flow in pipes and channels; unsteady and varied flows; wave motion. Prerequisite: CEE 341.

**546 Free Surface Hydraulics.** (3) F '97  
Derivation of 1-dimensional equations used in open channel flow analysis; computations for uniform and nonuniform flows, unsteady flow, and flood routing. Mathematical and physical models. Prerequisite: CEE 341.

**547 Principles of River Engineering.** (3) N  
Uses of rivers, study of watershed, and channel processes. Sediment sources, yield, and control; hydrologic analysis. Case studies. Prerequisite: CEE 341 or instructor approval.

**548 Sedimentation Engineering.** (3) F '96  
Introduction to the transportation of granular sedimentary materials by moving fluids. Degradation, aggregation, and local scour in alluvial channels. Mathematical and physical models. Prerequisite: CEE 547 or instructor approval.

**550 Soil Behavior.** (3) S  
Physicochemical aspects of soil behavior, stabilization of soils, and engineering properties of soils. Prerequisite: CEE 351.

**551 Advanced Geotechnical Testing.** (3) S  
Odometer, triaxial (static and cyclic) back pressure saturated and unsaturated samples, pore pressure measurements, closed-loop computer-controlled testing, in-situ testing, and sampling. Lecture, lab. Prerequisite: CEE 351.

**552 Geological Engineering.** (3) S  
Geological investigations for engineering purposes, case histories, geologic structure, weathering, remote sensing, geophysics, and air photo interpretation for engineering site locations. Lecture, field trips. Prerequisite: CEE 351.

**553 Advanced Soil Mechanics.** (3) S  
Application of theories of elasticity and plasticity to soils, theories of consolidation, failure theories, and response to static and dynamic loading. Prerequisite: CEE 351.

**554 Shear Strength and Slope Stability.** (3) F  
Shear strength of saturated and unsaturated soils strength-deformation relationships, time-dependent strength parameters, effects of sampling, and advanced slope stability. Prerequisite: CEE 351.

**555 Advanced Foundations.** (3) S  
Deep foundations, braced excavations, anchored bulkheads, reinforced earth, and underpinning. Prerequisite: CEE 351.

**556 Seepage and Earth Dams.** (3) F  
Transient and steady state fluid flow through soil, confined and unconfined flow, pore water pressures, and application to earth dams. Prerequisite: CEE 351.

**557 Hazardous Waste: Site Assessment and Mitigation Measures.** (3) F  
Techniques for hazardous waste site assessment and mitigation. Case histories presented by instructor and guest speakers. Prerequisites: graduate standing; instructor approval.

**559 Earthquake Engineering.** (3) F  
Characteristics of earthquake motions, selection of design earthquakes, site response analyses, seismic slope stability, and liquefaction. Prerequisite: CEE 351.

**560 Soil and Groundwater Remediation.** (3) F  
Techniques for remediation of contaminated soils and groundwaters are presented with basic engineering principles. Prerequisite: instructor approval.

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

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

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

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

**563 Environmental Chemistry Laboratory.** (3) F

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

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

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

**573 Traffic Engineering.** (3) F

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

**574 Highway Capacity.** (3) S

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

**575 Traffic Flow Theory and Safety Analysis.** (3) S

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

**576 Airport Engineering.** (3) F

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

**577 Urban Transportation Planning.** (3) F

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

*Students enrolled in CEE 580, 590, 592, 599, 792, and 799 are required to attend graduate student seminars at the times shown in the Schedule of Classes. Each semester, every graduate student enrolled for more than eight semester hours is to enroll for at least one semester hour of CEE 592, 599, 792, or 799. Each civil engineering graduate student holding an appointment as a teaching or research assistant or associate is to enroll for one semester hour of CEE 580; such credit does not apply toward graduation.*

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## Department of Computer Science and Engineering

**Stephen S. Yau**  
*Chair*  
(GWC 206) 602/965-3190

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**PROFESSORS**

ASHCROFT, BARNHILL,  
BLACKLEDGE, COLLOFELLO, FARIN,  
FINDLER, FOLEY, GOLSHANI, LEWIS,  
NIELSON, J. URBAN, WOODFILL, YAU

**ASSOCIATE PROFESSORS**

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

**ASSISTANT PROFESSORS**

CALLISS, ELGOT-DRAPKIN,  
KAMBHAMPATI

**PROFESSOR EMERITUS**

ROBBINS

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

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

**DEGREE REQUIREMENTS**

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

**GRADUATION REQUIREMENTS**

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

**Computer Science—B.S.**

The Department of Computer Science and Engineering offers a B.S. degree that prepares the student for a career in computer science. A student pursuing a B.S. degree must complete the First-Year Composition requirement, the General Studies requirement, department degree requirements, the computer science core courses, a senior-level breadth requirement in the major, technical electives, and unrestricted electives. More detail on these requirements is available at the department office and on pages 71–94. Further information on the department is available on the World Wide Web at the address: <http://www.eas.asu.edu/~csdept>, or by e-mail at: [cse.ugrad.desk@asu.edu](mailto:cse.ugrad.desk@asu.edu).

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

**First-Year Composition** (6 or 3)

ENG 101, 102	First-Year	
	Composition .....	6
	or ENG 105	
	Advanced First-Year	
	Composition (3)	

**General Studies/Department Requirements** (59)

	Humanities and Fine Arts and	
	Social and Behavioral Sciences.....	18
	Literacy and Critical Inquiry.....	6
	Natural and Basic Sciences .....	14–16
PHY 121	University Physics I: Mechanics S1/S2 <sup>1</sup> (3)	
PHY 122	University Physics Laboratory I S1/S2 <sup>1</sup> (1)	

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

PHY 131 University Physics II: Electricity and Magnetism *S1/S2*<sup>2</sup> (3)

PHY 132 University Physics Laboratory II *S1/S2*<sup>2</sup> (1)

Science electives (6–8)

Numeracy/Mathematics.....21

ECE 380 Probability and Statistics for Engineering Problem Solving (3)

MAT 243 Discrete Mathematical Structures (3)

MAT 270 Calculus with Analytic Geometry I *N1* (4)

MAT 271 Calculus with Analytic Geometry II (4)

MAT 272 Calculus with Analytic Geometry III (4)

MAT 342 Linear Algebra (3)

These electives may be satisfied by any physics courses requiring PHY 131 as a prerequisite or any laboratory science satisfying the S1 or S2 General Studies requirements (except PHS 110, PHY 101, 105, 111, or 112).

In addition, the following courses constitute the Computer Science core:

**Computer Science Core**

CSE 120 Digital Design Fundamentals .....3

CSE 200 Concepts of Computer Science *N3*..... 3

CSE 210 Data Structures and Algorithms I *N3*..... 3

CSE 225 Assembly Language Programming and Microprocessors (Motorola) *N3*..... 4 or CSE 226 Assembly Language Programming and Microprocessors (Intel) *N3* (4)

CSE 240 Introduction to Programming Languages.....3

CSE 310 Data Structures and Algorithms II .....3

CSE 330 Computer Organization and Architecture .....3

CSE 340 Principles of Programming Languages.....3

CSE 355 Introduction to Theoretical Computer Science .....3

CSE 360 Introduction to Software Engineering .....3

CSE 430 Operating Systems.....3

Total computer science core.....34

Computer science breadth requirement....18  
Each student must complete 18 hours of CSE 400-level courses.

Technical electives .....6  
Each student must complete six hours of courses chosen from the computer science technical elective

list and approved by the student's advisor.

Unrestricted electives .....5

Total degree requirements.....128

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

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

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

**First Semester**

CSE 200 Principles of Computing *N3*.. 3

ENG 101 First-Year Composition.....3

MAT 270 Calculus with Analytic Geometry I *N1*..... 4

HU, SB, awareness area courses<sup>1</sup> ..... 3

Laboratory science<sup>2</sup> *S1*..... 3

Total .....16

**Second Semester**

CSE 120 Digital Design Fundamentals .....3

CSE 210 Data Structures and Algorithms I *N3*..... 3

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

MAT 271 Calculus with Analytic Geometry II .....4

Laboratory science<sup>2</sup> *S2*..... 3

Total .....16

**Sophomore Year**

**First Semester**

CSE 240 Introduction to Programming Languages.....3

MAT 243 Discrete Mathematical Structures.....3

MAT 272 Calculus with Analytic Geometry III.....4

PHY 121 University Physics I: Mechanics *S1/S2*<sup>3</sup> ..... 3

PHY 122 University Physics Laboratory I *S1/S2*<sup>3</sup> ..... 1

HU, SB, awareness area courses<sup>1</sup> ..... 3

Total .....17

**Second Semester**

CSE 225 Assembly Language Programming and Microprocessors (Motorola) *N3*..... 4

CSE 310 Data Structures and Algorithms II .....3

PHY 131 University Physics II: Electricity and Magnetism *S1/S2*<sup>4</sup> ..... 3

PHY 132 University Physics Laboratory II *S1/S2*<sup>4</sup> ..... 1

HU, SB, awareness area courses<sup>1</sup> ..... 3

L1 elective .....3

Total .....17

**Junior Year**

**First Semester**

CSE 330 Computer Organization and Architecture .....3

CSE 340 Principles of Programming Languages .....3

MAT 342 Linear Algebra.....3

HU, SB, awareness area courses<sup>1</sup> ..... 3

Unrestricted elective.....3

Total .....15

**Second Semester**

CSE 355 Introduction to Theoretical Computer Science .....3

CSE 360 Introduction to Software Engineering .....3

CSE 430 Operating Systems.....3

ECE 380 Probability and Statistics for Engineering Problem Solving *N2*..... 3

HU, SB, awareness area courses<sup>1</sup> ..... 3

Unrestricted elective.....2

Total .....17

**Senior Year**

**First Semester**

400-level CSE computer science breadth electives .....9

L2 elective .....3

Technical elective.....3

Total .....15

**Second Semester**

HU, SB, awareness area courses<sup>1</sup> ..... 3

400-level CSE computer science breadth electives .....9

Technical elective.....3

Total .....15

<sup>1</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 277.

<sup>2</sup> Any physics courses requiring PHY 131 as a prerequisite or any laboratory science course satisfying the S1 or S2 General Studies requirements (except PHS 110; PHY 101, 105, 111, 112).

<sup>3</sup> Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

<sup>4</sup> Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

**Computer Systems Engineering—B.S.E.**

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

**First-Year Composition** (6 or 3)  
 ENG 101, 102 First-Year  
 Composition .....6  
 or ENG 105  
 Advanced First-Year  
 Composition (3)

**General Studies/Department  
 Requirements** (65)  
 Humanities and Fine Arts and  
 Social and Behavioral Sciences.....16

ECN 111 Macroeconomic  
 Principles *SB* (3)  
 or ECN 112 Microeconomic  
 Principles *SB* (3)  
 HU/SB electives (13)

Literacy and Critical Inquiry.....6  
 CSE 423 Microcomputer System  
 Hardware (3)  
 ECE 300 Intermediate Engineering  
 Design *LI* (3)

Natural and Basic Sciences .....15  
 CHM 114 General Chemistry for  
 Engineers *SI/S2* (4)  
 or CHM 116 General  
 Chemistry *SI/S2* (4)

PHY 121 University Physics I:  
 Mechanics *SI/S2*<sup>1</sup> (3)  
 PHY 122 University Physics  
 Laboratory I *SI/S2*<sup>1</sup> (1)  
 PHY 131 University Physics II:  
 Electricity and Magnetism  
*SI/S2*<sup>2</sup> (3)  
 PHY 132 University Physics  
 Laboratory II *SI/S2*<sup>2</sup> (1)  
 PHY 361 Introductory Modern  
 Physics (3)

Numeracy/Mathematics.....28  
 ECE 100 Introduction to Engineering  
 Design *N3* (4)  
 ECE 380 Probability and Statistics for  
 Engineering Problem  
 Solving (3)

MAT 243 Discrete Mathematical  
 Structures (3)  
 MAT 270 Calculus with Analytic  
 Geometry I *NI* (4)  
 MAT 271 Calculus with Analytic  
 Geometry II (4)  
 MAT 272 Calculus with Analytic  
 Geometry III (4)  
 MAT 274 Elementary Differential  
 Equations (3)  
 MAT 342 Linear Algebra (3)

**Engineering Core** (18)  
 CSE 200 Principles of  
 Computing *N3* ..... 3  
 CSE 225 Assembly Language  
 Programming and Micro-  
 processors (Motorola) *N3*..... 4  
 or CSE 226 Assembly  
 Language Programming and  
 Microprocessors (Intel) *N3* (4)

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

**Computer Science Core** (39)  
 CSE 120 Digital Design  
 Fundamentals .....3  
 CSE 210 Data Structures and  
 Algorithms I *N3*..... 3  
 CSE 240 Introduction to Programming  
 Languages.....3  
 CSE 310 Data Structures and  
 Algorithms II .....3  
 CSE 330 Computer Organization  
 and Architecture .....3  
 CSE 340 Principles of Programming  
 Languages.....3  
 CSE 355 Introduction to Theoretical  
 Computer Science .....3  
 CSE 360 Introduction to Software  
 Engineering .....3  
 CSE 421 Microprocessor System  
 Design I .....4  
 CSE 422 Microprocessor System  
 Design II .....4  
 CSE 430 Operating Systems.....3  
 Technical electives .....4  
 Each student must complete four  
 hours of courses chosen from the  
 computer science technical elective  
 list and approved by the student's  
 advisor.  
 Total .....128

<sup>1</sup> Both PHY 121 and 122 must be taken to  
 secure S1 or S2 credit.  
<sup>2</sup> Both PHY 131 and 132 must be taken to  
 secure S1 or S2 credit.

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

**First Semester**  
 CSE 200 Principles of Computing *N3*.. 3  
 ECE 100 Introduction to Engineering  
 Design *N3*..... 4  
 ECN 111 Macroeconomic  
 Principles *SB* ..... 3  
 ENG 101 First-Year Composition.....3  
 MAT 270 Calculus I *NI*..... 4  
 Total .....17

**Second Semester**  
 CHM 114 General Chemistry for  
 Engineers *SI/S2*..... 4  
 CSE 120 Digital Design  
 Fundamentals .....3  
 CSE 210 Data Structures and  
 Algorithms I *N3*..... 3  
 ENG 102 First-Year Composition.....3

MAT 271 Calculus II .....4  
 Total .....17

**Sophomore Year**

**First Semester**  
 CSE 225 Assembly Language  
 Programming and  
 Microprocessors  
 (Motorola) *N3*..... 4  
 MAT 243 Discrete Mathematical  
 Structures.....3  
 MAT 272 Calculus III.....4  
 PHY 121 University Physics I:  
 Mechanics *SI/S2*<sup>1</sup> ..... 3  
 PHY 122 University Physics  
 Laboratory I *SI/S2*<sup>1</sup> ..... 1  
 Total .....15

**Second Semester**  
 CSE 240 Introduction to Programming  
 Languages.....3  
 CSE 330 Computer Organization  
 and Architecture .....3  
 ECE 300 Intermediate Engineering  
 Design *LI* .....3  
 MAT 274 Elementary Differential  
 Equations.....3  
 PHY 131 University Physics II:  
 Electricity and  
 Magnetism *SI/S2*<sup>2</sup> ..... 3  
 PHY 132 University Physics  
 Laboratory II *SI/S2*<sup>2</sup> ..... 1  
 Total .....16

**Junior Year**

**First Semester**  
 CSE 310 Data Structures and  
 Algorithms II .....3  
 ECE 210 Engineering Mechanics I:  
 Statics .....3  
 MAT 342 Linear Algebra.....3  
 HU, SB, awareness area courses<sup>3</sup> ..... 7  
 Total .....16

**Second Semester**  
 CSE 340 Principles of Programming  
 Languages.....3  
 CSE 360 Introduction to Software  
 Engineering .....3  
 CSE 421 Microprocessor System  
 Design I .....4  
 ECE 380 Probability and Statistics  
 for Engineering  
 Problem Solving.....3  
 HU, SB, awareness area courses<sup>3</sup> ..... 3  
 Total .....16

**Senior Year**

**First Semester**  
 CSE 355 Introduction to Theoretical  
 Computer Science .....3  
 CSE 422 Microprocessor System  
 Design II .....4

**NOTE:** For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

CSE	430	Operating Systems.....	3
ECE	301	Electrical Networks I.....	4
PHY	361	Introductory Modern Physics.....	3
Total .....			17

**Second Semester**

CSE	423	Microcomputer System Hardware .....	3
ECE	334	Electronic Devices and Instrumentation.....	4
HU, SB, awareness area courses <sup>3</sup> .....			3
Technical electives .....			4
Total .....			14

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

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

<sup>3</sup> Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 277.

## COMPUTER SCIENCE AND ENGINEERING

### **CSE 100 Introduction to Computer Science I.** (3) F, S, SS

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

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

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

### **180 Computer Literacy.** (3) F, S, SS

Introduction to general problem-solving approaches using widely available software tools such as database packages, word processors, spreadsheets, and report generators. IBM PC or Macintosh. Nonmajors only. *General Studies: N3.*

### **181 Applied Problem Solving with BASIC.** (3) F, S, SS

Introduction to systematic definition of problems, solution formulation, and method validation. Computer solution using BASIC required for projects. Lecture, lab. Nonmajors only. Prerequisite: MAT 117. *General Studies: N3.*

### **183 Applied Problem Solving with FORTRAN.** (3) F

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

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

Overview of algorithms, architecture, languages, operating systems, theory. Problem solving by programming with a high-level language (C or another). Lecture, lab. *General Studies: N3.*

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

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

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

Assembly language programming, including input/output programming and exception/interrupt handling. Register-level computer organization, I/O interfaces, assemblers, and linkers. Motorola-based assignments. Lecture, lab. Cross-listed as EEE 225. Prerequisite: CSE/EEE 120. *General Studies: N3.*

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

CPU/Memory/peripheral device interfaces and programming. System buses, interrupts, serial and parallel I/O, DMA, coprocessors. Intel-based assignments. Lecture, lab. Cross-listed as EEE 226. Prerequisite: CSE/EEE 120. *General Studies: N3.*

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

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

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

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

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

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

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

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

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

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

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

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

### **408 Multimedia Information Systems.** (3) F

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

### **410 Information Processing.** (3) A

Primary and secondary file access organizations. Multi-attribute indexing. File processing. Introduction to database management and document retrieval. Social and ethical implications. Prerequisite: CSE 310.

### **412 Database Management.** (3) F, S

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

### **420 Computer Architecture I.** (3) S

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

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

Assembly-language programming and logical hardware design of systems using 8-bit microprocessors and microcontrollers. Fundamental concepts of digital system design. Reliability and social, legal implications. Lecture, lab. Prerequisite: CSE/EEE 225 or 226.

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

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

### **423 Microcomputer System Hardware.** (3) S

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

### **428 Computer-Aided Processes.** (3) A

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

### **430 Operating Systems.** (3) F, S

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

### **434 Computer Networks.** (3) A

Computer network protocols, hardware elements, and software algorithms. Error handling, routing, flow control, host-to-host communication, and local area networks. Prerequisite: CSE 330.

### **438 Systems Programming.** (3) A

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

### **440 Compiler Construction I.** (3) F

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

- 450 Design and Analysis of Algorithms.** (3) F  
Design and analysis of computer algorithms using analytical and empirical methods; complexity measures, design methodologies, and survey of important algorithms. Prerequisite: CSE 310.
- 451 Switching Theory.** (3) N  
Combinational logic, functional decomposition, NAND (NOR) circuit analysis and synthesis, logic arrays, iterative networks, fault diagnosis, sequential circuit representation, and memory devices. Prerequisites: CSE 120; MAT 243.
- 457 Theory of Formal Languages.** (3) A  
Theory of grammar, methods of syntactic analysis and specification, types of artificial languages, relationship between formal languages, and automata. Cross-listed as MAT 401. Prerequisite: CSE 355.
- 459 Logic for Computing Scientists I.** (3) F  
Propositional logic, syntax and semantics, proof theory versus model theory, soundness, consistency and completeness, first order logic, logical theories, automated theorem proving, ground resolution, pattern matching unification and resolution, Dijkstras logic, proof obligations, and program proving. Prerequisite: CSE 355.
- 461 Software Engineering Senior Project I.** (3) F  
First of two-course software design sequence. Development planning, management; process modeling; incremental and team development using CASE tools. Lecture, lab. Prerequisites: CSE 360; ECE 400.
- 462 Software Engineering Senior Project II.** (3) S  
Second of two-course software design sequence. Process, product assessment and improvement; incremental and team development using CASE tools. Lecture, lab. Prerequisite: CSE 461.
- 470 Computer Graphics.** (3) F, S  
Display devices, data structures, transformations, interactive graphics, 3-dimensional graphics, and hidden line problem. Prerequisites: CSE 310; MAT 342.
- 471 Introduction to Artificial Intelligence.** (3) F, S  
State space search, heuristic search, games, knowledge representation techniques, expert systems, and automated reasoning. Prerequisites: CSE 240, 310.
- 473 Nonprocedural Programming Languages.** (3) S  
Functional and logic programming using languages like Lucid and Prolog. Typical applications would be a Screen Editor and an Expert System. Prerequisite: CSE 355.
- 476 Introduction to Natural Language Processing.** (3) F  
Principles of computational linguistics, formal syntax, and semantics, as applied to the design of software with natural (human) language I/O. Prerequisite: CSE 310 or instructor approval.
- 477 Introduction to Computer-Aided Geometric Design.** (3) F, S  
Introduction to parametric curves and surfaces, Bezier and B-spline interpolation, and approximation techniques. Prerequisites: CSE 210, 470; MAT 342.
- 510 Advanced Database Management.** (3) F, S  
Advanced data modeling, deductive databases, object-oriented databases, distributed and multidatabase systems; emerging database technologies. Prerequisite: CSE 412.
- 512 Distributed Databases.** (3) A  
Fragmentation design. Query optimization. Distributed joins. Concurrency control. Distributed deadlock detection. Prerequisite: CSE 510.
- 513 Deductive Databases.** (3) F  
Logic as a data model. Query optimization emphasizing the top-down and bottom-up evaluation of declarative rules. Prerequisite: CSE 510.
- 514 Object-Oriented Database Systems.** (3) A  
Object-oriented data modeling, database and language integration, object algebras, extensibility, transactions, object managers, versioning/configuration, active data, nonstandard applications. Research seminar. Prerequisite: CSE 510.
- 516 Digital Testing and Reliability.** (3) N  
Fault modeling, test generation, and simulation for combinational and sequential circuits; memory testing, self-checking logic, fault-tolerant logic, and reliability analysis. Prerequisite: CSE 423 or EEE 425 or instructor approval.
- 517 Hardware Design Languages.** (3) N  
Introduction to hardware design languages using VHDL. Modeling concepts for specification, simulation, and synthesis. Prerequisite: CSE 423 or EEE 425 or instructor approval.
- 518 Synthesis with Hardware Design Languages.** (3) N  
Modeling VLSI design in hardware design languages for synthesis. Transformation of language-based designs to physical layout. Application of synthesis tools. Prerequisite: CSE 517.
- 520 Computer Architecture II.** (3) F  
Computer architecture description languages, computer arithmetic, memory-hierarchy design, parallel, vector, and multiprocessors, and input/output. Prerequisites: CSE 420, 430.
- 521 Microprocessor Applications.** (4) S  
Microprocessor technology and its application to the design of practical digital systems. Hardware, assembly language programming, and interfacing of microprocessor-based systems. Lecture, lab. Prerequisite: CSE 421.
- 523 Microcomputer Systems Software.** (3) F  
Developing system software for a multiprocessor, multiprogramming, microprocessor-based system using information and techniques presented in CSE 421, 422. Prerequisite: CSE 422.
- 526 Parallel Processing.** (3) N  
Real and apparent concurrency. Hardware organization of multiprocessors, multiple computer systems, scientific attached processors, and other parallel systems. Prerequisite: CSE 330 or 423.
- 529 RISC Design Methodology.** (3) N  
Optimal computer architecture design methodology based on the symbiotic relationship of hardware and software disciplines. Prerequisite: CSE 330 or 423.
- 530 Operating System Internals.** (3) F  
Implementation of process management and synchronization, system call and interrupt handling, memory management, device drivers and file systems in UNIX. Prerequisites: CSE 430; knowledge of C language.
- 531 Distributed and Multiprocessor Operating Systems.** (3) N  
Distributed systems architecture, remote file access, message-based systems, object-based systems, client/server paradigms, distributed algorithms, replication and consistency, and multiprocessor operating systems. Prerequisite: CSE 530 or instructor approval.
- 532 Advanced Operating System Internals.** (3) F  
Memory, processor, process and communication management, and concurrency control in the Mach multiprocessor and distributed operating system kernels and servers. Prerequisite: CSE 530 or instructor approval.
- 535 Performance Evaluation.** (3) S  
Topics in computer system measurement and evaluation, including hardware/software monitors, workload characterization, program behavior, adaptive scheduling, simulation models, and measurement interpretation. Prerequisite: CSE 430.
- 536 Theory of Operating Systems.** (3) S  
Protection. Communication and synchronization in distributed systems, distributed file systems, deadlock theory, virtual memory theory, and uniprocessor and multiprocessor thread management. Prerequisite: CSE 430.
- 540 Compiler Construction II.** (3) S  
Formal parsing strategies, optimization techniques, code generation, extensibility and transportability considerations, and recent developments. Prerequisite: CSE 440.
- 545 Programming Language Design.** (3) N  
Language constructs, extensibility and abstractions, and runtime support. Language design process. Prerequisite: CSE 440.
- 550 Combinatorial Algorithms and Intractability.** (3) N  
Combinatorial algorithms, nondeterministic algorithms, classes P and NP, NP-hard and NP-complete problems, and intractability. Design techniques for fast combinatorial algorithms. Prerequisite: CSE 450.
- 554 Advanced Switching Theory.** (3) S  
Lattices, Boolean algebras, post algebras, Boolean differential calculus, multivalued logic, fuzzy logic, and finite state machines. Prerequisite: CSE 451.

**555 Automata Theory.** (3) N

Finite state machines, pushdown automata, linear bounded automata, Turing machines, register machines, rams, and rasps; relationships to computability and formal languages. Prerequisite: CSE 355.

**556 Expert Systems.** (3) S

Knowledge acquisition and representation, rule-based systems, frame-based systems, validation of knowledge bases, inexact reasoning, and expert database systems. Prerequisite: CSE 471.

**560 Software Engineering.** (3) F, S

Software engineering foundations, formal representations in the software process; use of formalisms in creating a measured and structured working environment. Lecture, lab. Prerequisite: CSE 360.

**562 Parallel and Distributed Software Engineering.** (3) A

Software engineering characteristics particular to parallel and distributed systems. Tools and techniques to support software engineering involving parallel processing and distributed systems. Prerequisite: CSE 560.

**563 Software Requirements and Specification.** (3) A

Examination of the definitional stage of software development; analysis of specification representations, formal methods, and techniques emphasizing important application issues. Prerequisite: CSE 560.

**564 Software Design.** (3) A

Examination of software design issues and techniques. Includes a survey of design representations and a comparison of design methods. Prerequisite: CSE 560.

**565 Software Verification, Validation, and Testing.** (3) A

Test planning, requirements-based and code-based testing techniques, tools, reliability models, and statistical testing. Prerequisite: CSE 560.

**566 Software Project, Process, and Quality Management.** (3) A

Project management, risk management, configuration management, quality management, and simulated project management experiences. Prerequisite: CSE 560.

**570 Advanced Computer Graphics I.** (3) F

Hidden surface algorithms, lighting models, and shading techniques. User interface design. Animation techniques. Fractals and stochastic models. Raster algorithms. Prerequisite: CSE 470.

**571 Artificial Intelligence.** (3) S

Definitions of intelligence, computer problem solving, game playing, pattern recognition, theorem proving, and semantic information processing; evolutionary systems; heuristic programming. Prerequisite: CSE 471.

**573 Advanced Computer Graphics II.** (3) S

Modelling of natural phenomena: terrain, clouds, fire, water, and trees. Particle systems, deformation of solids, antialiasing, and volume visualization. Lecture, lab. Prerequisite: CSE 470.

**574 Planning and Learning Methods in AI.** (3) F '97

Reasoning about time and action, plan synthesis and execution, improving planning performance, applications to manufacturing intelligent agents. Prerequisite: CSE 471 or equivalent.

**575 Decision-Making Strategies in AI.** (3) S

Automatic knowledge acquisition, automatic analysis/synthesis of strategies, distributed planning/problem solving, causal modeling, predictive human-machine environments. Prerequisite: CSE 471 or 571 or equivalent.

**576 Topics in Natural Language Processing.** (3) S

Comparative parsing strategies, scoping and reference problems, non-first-order logical semantic representations, and discourse structure. Prerequisite: CSE 476 or instructor approval.

**577 Advanced Computer-Aided Geometric Design I.** (3) F

General interpolation; review of curve interpolation and approximation; spline curves; visual smoothness of curves; parameterization of curves; introduction to surface interpolation and approximation. Prerequisites: CSE 470, 477; or instructor approval.

**578 Advanced Computer-Aided Geometric Design II.** (3) S

Coons patches and Bezier patches; triangular patches; arbitrarily located data methods; geometry processing of surfaces; higher dimensional surfaces. Prerequisites: CSE 470, 477; or instructor approval.

**579 NURBs: Non-Uniform Rational B-Splines.** (3) S

Projective geometry, NURBs-based modeling, basic theory of conics and rational Bezier curves, rational B-splines, surfaces, rational surfaces, stereographic maps, quadrics, IGES data specification Prerequisites: CSE 470, 477.