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 construction. Considerable effort is spent on the development and delivery of well-rounded programs that enhance student preparation for professional careers, lifelong learning, and responsible participation as a member of society.

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

ORGANIZATION

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

Del E. Webb School of Construction

School of Engineering

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

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

Center for Innovation in Engineering Education
Center for Low Power Electronics
Center for Research in Engineering and Applied Sciences
Center for Solid-State Electronics Research
Manufacturing Institute
Center for System Science and Engineering Research
Telecommunications Research Center

Center for Professional Development. The Center for Professional Development, often in cooperation with the college's academic units and research centers, provides a variety of technical conferences, seminars, short courses, and televised and satellite-transmitted programs to enable engineers, scientists, and managers to continue the 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 EC G148, at 602/965–1740, by e-mail at asu.cpd@asu.edu, or visit the center's Web site at www.eas.asu.edu/cpd.

ADMISSION

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

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

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

Professional Status. For admission to *professional status*, Arizona residents must meet one of the requirements as listed in the table, "Professional Status Requirements for Residents," and a nonresident must meet one of the requirements as listed in the table, "Professional Status Requirements for Nonresidents" on this page. 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 60, "Undergraduate Admission," may be admitted as a *preprofessional* student to any one of the academic programs of the college. International students whose TOEFL scores do not meet the required minimum shown in the tables below may also be admitted to preprofessional status. A student admitted into this classification follows the freshman-sophomore sequence of courses as required by the chosen major. Courses are selected with the assistance of an academic advisor. After completing a minimum of 30 semester hours of required or approved elective courses *with a cumulative GPA equivalent to that required of transfer students and corresponding to the chosen major*, students may apply for admission to professional status. *International students must also submit a TOEFL score equivalent to that required for admission to professional status* (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 in the table, "Professional Status Requirements for Transfer Students," on page 186.

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

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

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

Credit is granted for transferred courses deemed equivalent to corresponding courses in the selected program of study, subject to grade and ASU resident credit requirements. No grades lower than "C" are accepted as transfer credit to meet the graduation requirements of this college. Credits transferred from a community college or two-year institution are applied only as lower-division credits. Prospective Arizona community college transfer students should consult their advisors and refer to the annual *Arizona Higher Education Course Equivalency Guide* (CEG) 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 academic unit with the approval of the dean.

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

Professional Status Requirements for Residents

		Minimum Scores	
School	High School Rank	ACT	SAT
Construction	Upper 25%	23	1140
Engineering	Upper 25%	23	1140

Professional Status Requirements for Nonresidents

		Minimum Scores		
School	High School Rank	ACT	SAT	TOEFL*
Construction	Upper 25%	24	1140	550
Engineering	Upper 25%	24	1140	550

* For international students (see page 64).

Professional Status Requirements for Transfer Students

School	Transfer GPA[1]		
	Resident	Nonresident	TOEFL[2]
Construction	2.25	2.50	550
Engineering	2.50	2.50	550

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

[2] For international students (see page 64).

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

To maintain continuous student status in the university, each co-op student must be enrolled in ASE 399 Cooperative Work Experience for one semester hour during each work session. Such credit cannot be applied toward degree requirements. For more information, contact the director of Student Academic Services at 602/965–1750 (EC G102) 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.

DEGREES

The faculty in the College of Engineering and Applied Sciences offer programs leading to the B.S. and B.S.E. degrees with majors in the subjects shown in the “College of Engineering and Applied Sciences Degrees, Majors, and Concentrations” table, pages 187–188. Each major is administered by the academic unit indicated.

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

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

GRADUATE PROGRAMS

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

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

DEGREE REQUIREMENTS

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

UNIVERSITY GRADUATION REQUIREMENTS

In addition to department and school requirements, students must meet all university graduation requirements (see pages 79–83). 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 84–87. General Studies courses are listed on pages 87–108 in the *General Catalog,* in the course descriptions, in the *Schedule of Classes,* and in the *Summer Sessions Bulletin.* Note that all three General Studies awareness areas are required. Consult your advisor for an approved list of courses.

First-Year Composition Requirement

As a minimum, completion of ENG 101 and 102, or ENG 107 and 108, or ENG 105 with grades of “C” or higher is required for graduation from ASU in any baccalaureate program. See “First-Year Composition Requirement,” page 79. Any student whose written or spoken English in any course is unsatisfactory may be required by the appropriate director or department chair to take additional course work.

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

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

[1] This major requires more than 120 semester hours to complete.

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

Major	Degree	Administered by
Graduate Degrees		
Del E. Webb School of Construction		
Construction Concentrations: construction science, facilities, management	M.S.	Del E. Webb School of Construction
School of Engineering		
Aerospace Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Bioengineering	M.S., Ph.D.	Department of Chemical, Bio, and Materials Engineering
Chemical Engineering Concentrations: biomedical and clinical engineering, chemical process engineering, chemical reactor engineering, energy and materials conversion, environmental control, solid-state processing, transport phenomena	M.S., M.S.E., Ph.D.	Department of Chemical, Bio, and Materials Engineering
Civil Engineering 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	M.S., M.S.E., Ph.D.	Department of Industrial and Management Systems Engineering
Mechanical Engineering	M.S., M.S.E., Ph.D.	Department of Mechanical and Aerospace Engineering
Science and Engineering of Materials Concentrations: high-resolution nanostructure analysis, solid-state device materials design	Ph.D.[3]	Committee on the Science and Engineering of Materials

1 This major requires more than 120 semester hours to complete.

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

3 This program is administered by the Graduate College. See “Graduate College,” pages 282–292.

COLLEGE DEGREE REQUIREMENTS

Pass/Fail Grades

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

Entry into Upper-Division Courses

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

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

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.

MAJOR REQUIREMENTS

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

ACADEMIC STANDARDS

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

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

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

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

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

Disqualification. During a semester on academic probation, a student who fails to meet the retention standards specified above is disqualified. Students may request a review of their disqualification status by contacting the associate director of Student Academic Services in EC G102. 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 at least 15 semester hours of pertinent courses in the discipline at a community college with higher than average grades, and a cumulative GPA of 2.50 or higher for all courses completed.

STUDENT RESPONSIBILITIES

Course Prerequisites. Students should consult the *Schedule of Classes* and the catalog for course prerequisites. Students who register for courses without the designated prerequisites may be withdrawn without the student's consent at any time before the final examination. Such withdrawal may be initiated by the instructor, the chair of the department offering the course, the director of Student Academic Services, or the dean of the college. In such cases, students will not receive monetary reimbursement. However, such withdrawal is considered to be unrestricted as described on page 73 and does not count against the number of restricted withdrawals allowed.

SPECIAL PROGRAMS

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

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

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

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

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

Students interested in these programs should see their department advisor or inquire in the office of the Center for Innovation in Engineering Education in room EC G205 or call 602/965–5350, or visit our Web site at www.eas.asu.edu/~asufc.

Minority Engineering Program. The staff of the Minority Engineering Program (MEP) is available to assist the academic and professional development of prospective, newly admitted, and continuing students through a variety of support services. In addition, advice on financial aid, scholarships, and employment is provided. Visit the MEP office located in room EC G307 or call 602/965–8275, or visit our Web site at www.eas.asu.edu/~omep.

Women in Applied Sciences and Engineering Program. The Women in Applied Sciences and Engineering (WISE) Program hosts seminars and workshops, and provides outreach programs to high school and community college students. WISE offers a professional development course, STE 194 Engineering for Undecided, to acquaint students with a variety of technical careers. The WISE Center, located in room EC G214, is open for study groups, tutoring, and informal discussions. The phone number is 602/965–6882. The Web address is www.eas.asu.edu/~wise.

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

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

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

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

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

University Honors College. The College of Engineering and Applied Sciences participates in the programs of the University Honors College, which provides enhanced educational experiences to academically superior undergraduate students. Participating students can major in any academic program. A description of the requirements and the opportunities offered by the University Honors College can be found on pages 293–295.

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

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

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

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

Office of the Administrative Vice President
Grand Canyon University
3300 W Camelback Rd
Phoenix AZ 85017–1097

Provost and Dean of the Brown College of Arts and Sciences
Southwestern University
Georgetown TX 78626

Dean, College of Arts and Sciences
C.W. Post Campus
Long Island University
Brookville NY 11548

Office of the Dean
College of Engineering and Applied Sciences
Arizona State University
PO Box 875506
Tempe AZ 85287–5506

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

GENERAL INFORMATION

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

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

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

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

Del E. Webb School of Construction

William W. Badger
Director
(JWS 268) 602/965–3615
www.eas.asu.edu/dewsc

PROFESSORS
BADGER, MULLIGAN

ASSOCIATE PROFESSORS
BASHFORD, ERNZEN, WEBER

ASSISTANT PROFESSORS
CHASEY, KASHIWAGI, WALSH, WIEZEL

VISITING EMINENT SCHOLAR
SCHEXNAYDER

PURPOSE

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

DEGREES

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

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

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

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

SPECIAL PROGRAMS

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

ASU 3+2 Program. The Del E. Webb School of Construction also participates in the ASU 3+2 program with Grand Canyon University and Southwestern University. See page 190 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 59–78, 184–185, and 188–189 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 79) must be completed by the time the student has accumulated 48 semester hours of program requirements, and (2) all second-semester, first-year courses must be completed by the time the student has completed 64 semester hours of program requirements. Transfer students are given a one-semester waiver.

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

DEGREE REQUIREMENTS

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

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy the General Studies requirements as noted on pages 84–87 and all university graduation requirements as noted on pages 79–83. Note that all three General Studies awareness areas are required. Consult your advisor for an approved list of courses.

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

SCHOOL COURSE REQUIREMENTS

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

Humanities and Fine Arts/ Social and Behavioral Sciences

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

Literacy and Critical Inquiry

COM	225	Public Speaking *L1*	3
ECE	400	Engineering Communications *L2* or ETC 400 Technical Communications *L2* (3)	3
Total			6

Natural Sciences

PHY	111	General Physics *S1/S2*[1]	3
PHY	112	General Physics *S1/S2*[2]	3
PHY	113	General Physics Laboratory *S1/S2*[1]	1
PHY	114	General Physics Laboratory *S1/S2*[2]	1
Natural Sciences total			8

Numeracy

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

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

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

[3] Because of the school's requirement for MAT 270, the total semester hours exceed the General Studies requirement of 35.

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

ACC	394	ST: Financial Analysis and Accounting for Small Businesses	3
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	3
CON	495	Construction Planning and Scheduling *N3*	3
CON	496	Construction Contract Administration *L2*	3
ECE	100	Introduction to Engineering Design *N3*	4
LES	306	Business Law	3
Science elective with lab			4
Total common to all options			71

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

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

First Semester

CON	101	Construction and Culture: A Built Environment *HU, G, H*	3
ECN	111	Macroeconomic Principles *SB*	3
ENG	101	First-Year Composition	3
MAT	270	Calculus with Analytic Geometry I *N1*	4
PHY	111	General Physics *S1/S2*[1]	3
PHY	113	General Physics Laboratory *S1/S2*[1]	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*[2]	3
PHY	114	General Physics Laboratory *S1/S2*[2]	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

Fourth Semester

ACC	394	ST: Financial Analysis and Accounting for Small Businesses	3
COM	225	Public Speaking *L1*	3
CON	252	Building Construction Methods, Materials, and Equipment	3
CON	273	Electrical Construction Fundamentals	3
CON	323	Strength of Materials	3
Total			15

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

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

Option in General Building Construction

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

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

Requirements

CON	472	Development Feasibility Reports *L2*	3
CON	483	Advanced Building Estimating	3
PUP	432	Planning and Development Control Law or PUP 433 Zoning Ordinances, Subdivision Regulations, and Building Codes (3)	3
REA	394	Real Estate Fundamentals	3
Upper-Division Technical Elective			3
Total			15

Option in Heavy Construction

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

Requirements

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

Option in Residential Construction

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

Requirements

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

Option in Specialty Construction

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

Requirements

CON	455	Construction Office Methods	3
CON	468	Mechanical and Electrical Estimating	3
Upper-division technical electives			9
Total			15

CONSTRUCTION (CON)

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

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

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

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

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

CON 273 Electrical Construction Fundamentals. (3) F, S
Circuits and machinery. Power transmission and distribution, with emphasis on secondary distribution systems. Measurements and instrumentation. Lecture, field trips. Prerequisites: MAT 270 or equivalent; PHY 112, 114.

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

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

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

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

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

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

CON 383 Construction Estimating. (3) F, S
Drawings and specifications. Methods and techniques used in construction estimating procedures. Introduction to computer software used in industry. Lecture, project workshops. Prerequisites: CON 243 and 251 and 252 and 273 and Construction major *or* instructor approval.

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

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

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

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

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

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

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

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

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

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

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

CON 496 Construction Contract Administration. (3) F, S
Survey administrative procedures of general and subcontractors. Study documentation, claims, arbitration, litigation, bonding, insurance, and indemnification. Discuss ethical practices. Lecture, field trips. Prerequisites: ECE 400 (or ETC 400); senior standing. Pre- or corequisite: CON 371. *General Studies: L2.*

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

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

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

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

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

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

CON 577 Construction Systems Engineering. (3) F
Systems theory as applied to the construction process. Alternates for structuring information flows and the control of projects. Prerequisite: IEE 476 or equivalent.

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

School of Engineering

Daniel F. Jankowski
Director
(EC G104) 602/965–1726

PURPOSE

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

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

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

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

ADMISSION

See pages 59–78, 184–185, and 188–189 for information regarding requirements for admission, transfer, retention, disqualification, and reinstatement.

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

DEGREES

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

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

2. an engineering core; and
3. a major.

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

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

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

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

In addition to First-Year Composition, the university requires, under the heading of General Studies, courses in literacy and critical inquiry, humanities and fine arts, social and behavioral sciences, numeracy, and natural sciences (see pages 84–87). There are also requirements in historical awareness, global awareness, and cultural diversity in the United States. ABET and CSAB impose additional requirements, particularly in mathematics and the basic sciences and in the courses for the major.

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

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

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

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

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

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

Typical Freshman Year

First Semester

CHM	114	General Chemistry for Engineers *S1/S2*	4
ECE	100	Introduction to Engineering Design *N3*	4
ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
ENG	101	First-Year Composition	3
ENG	102	First-Year Composition	3
MAT	270	Calculus with Analytic Geometry I *N1*	4
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 course			3
Total			32

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

Well-prepared students who have no outside commitments can usually complete the program of study leading

Under direction from regents' professor John Spence (center), Uwe Weierstall (left) and research assistant J.M. Zuo work on silicon surface reconstruction.

Tim Trumble photo

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 79) and the literacy and critical inquiry component (see page 85) of the General Studies requirement, which involves two courses beyond First-Year Composition.
2. *Selected nonengineering topics.* This area ensures that the engineering student acquires a satisfactory level of basic knowledge in the humanities and fine arts, social and behavioral sciences, numeracy, and the natural sciences. Courses in these subjects give engineers an increased awareness of their social responsibilities, provide an understanding of related factors in the decision-making process, and also provide a foundation for the study of engineering. Required courses go toward fulfilling the General Studies requirement. Additional courses in mathematics and the basic sciences are selected to meet ABET requirements.

   Because of accreditation requirements, aerospace studies (AES) and military science (MIS) courses are not acceptable for engineering degree credit in fulfilling the humanities and fine arts and social and behavioral science portions of the General Studies requirement.
3. *Selected engineering topics.* This area involves courses in engineering science and engineering design. The courses further develop the foundation for the study of engineering and provide the base for specialized studies in a particular engineering discipline. The specific courses are included in the engineering core and in the major. While some departmental choices are allowed, all students are required to take ECE 100 Introduction to Engineering Design and ECE 300 Intermediate Engineering Design as part of the engineering core. These courses, together with other experiences in the engineering core and in the major, serve to integrate the study of design, the "process of devising a system, component, or process to meet desired needs" (ABET), throughout the engineering curricula.
4. *Specific engineering discipline.* This area provides a depth of understanding of a more definitive body of knowledge that is appropriate for a specific engineering discipline. Courses build upon the background provided by the earlier completed portions of the curriculum and include a major design experience as well as technical electives that may be selected by the student with the assistance of an advisor. The catalog material for the individual engineering majors describes specific departmental requirements.

COURSE REQUIREMENTS

A summary of the degree requirements is as follows:

First-Year Composition	3–6
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	128

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

First-Year Composition

ENG	101, 102	First-Year Composition or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	6
Total			6

General Studies/School Requirements

Humanities and Fine Arts/
Social and Behavioral Sciences
Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements.

ECN	111	Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3)	3
HU course(s)			6 or 10
SB course(s)			7 or 3
Total			16

Literacy and Critical Inquiry

ECE	300	Intermediate Engineering Design *L1*	3
ECE	400	Engineering Communications *L2* or approved department L2 course (3)	3
Total			6

Natural Sciences/Basic Sciences

CHM	114	General Chemistry for Engineers *S1/S2* or CHM 116 General Chemistry *S1/S2* (4)	4
PHY	121	University Physics I: Mechanics *S1/S2*[1]	3
PHY	122	University Physics Laboratory I *S1/S2*[1]	1
PHY	131	University Physics II: Electricity and Magnetism *S1/S2*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

Department basic science elective			3
Total			15

Numeracy/Mathematics

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
Total			21
General Studies/school requirements total			58

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

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

Engineering Core

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

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

GRADUATION REQUIREMENTS

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

PROFESSIONAL ACCREDITATION

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

ANALYSIS AND SYSTEMS (ASE)

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

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

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

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

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

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

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

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

ENGINEERING CORE (ECE)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ECE 400 Engineering Communications. (3) F, S, SS
Planning and preparing engineering publications and oral presentations, based on directed library research related to current engineering topics. Prerequisites: ENG 102 (or 105 or 108); completion of General Studies L1 requirement (or ECE 300); senior standing in an engineering major. *General Studies: L2.*

SOCIETY, VALUES, AND TECHNOLOGY (STE)

STE 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 or 108. *General Studies: L1.*

STE 208 Patterns in Nature. (4) F, S
Project-oriented science course with computer training to develop critical thinking, and technical skills for student-oriented science lessons K–12. Lecture, lab. Cross-listed as PHS 208. Prerequisite: college-level science course or instructor approval. *General Studies: S1/S2.*

Department of Chemical, Bio, and Materials Engineering

Eric J. Guilbeau
Chair
(EC G202) 602/965–3313
www.eas.asu.edu/~cbme

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

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

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

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

The following sections describe the curriculum requirements for the Bachelor of Science in Engineering degree in each of these disciplines. Faculty within the department also participate in the Engineering Special Studies program in premedical engineering which is described separately on page 238.

CHEMICAL ENGINEERING—B.S.E.

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

ASSOCIATE PROFESSORS
BECKMAN, BELLAMY, BURROWS, GARCIA, RIVERA, TORREST

ASSISTANT PROFESSOR
S. BEAUDOIN

LECTURER
D. BEAUDOIN

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

Consequently, in addition to the chemical and petroleum industries, chemical engineers find challenging opportunities in the plastics, solid-state, electronics, computer, metals, space, food, drug, and health care industries, where they practice in a wide variety of occupations, such as environmental control, surface treatments, energy and materials transformations, biomedical applications, fermentation, protein recovery, extractive metallurgy, and separations. While a large percentage of the industrial positions are filled by graduates with bachelor's degrees, there are lucrative and creative opportunities in research and development for those who acquire postgraduate education.

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

DEGREE REQUIREMENTS

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

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

First-Year Composition

ENG	101, 102	First-Year Composition or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	6
Total			6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

ECN	111	Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3)	3
SB, HU, and awareness area courses[1]			13
Total			16

Literacy and Critical Inquiry

CHE	352	Transport Laboratories *L2*	3
ECE	300	Intermediate Engineering Design *L1*	3
Total			6

Natural Sciences/Basic Sciences

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

Numeracy/Mathematics

ECE	100	Introduction to Engineering Design *N3*	4
ECE	384	Numerical Analysis for Engineers I	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
Total			21
General Studies/school requirements total			59

Engineering Core

CHE	342	Applied Chemical Thermodynamics	4
CHE	461	Process Control *N3*	4
ECE	394	ST: Conservation Principles	4
ECE	394	ST: Properties that Matter	4
ECE	394	ST: Engineering Systems	4
Total			20

Major

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

---

[1] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 195.

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

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

The technical elective courses must be selected from upper-division courses with an advisor's approval and must include 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 faculty in the Department of Chemical, Bio, and Materials Engineering also offer graduate programs leading to the M.S.E., M.S., and Ph.D. degrees. These programs provide a blend of classroom instruction and research. A wide variety of topical and relevant research projects are available for thesis topics. Students interested in these programs should contact the department for up-to-date descriptive literature.

Chemical Engineering Areas of Emphasis

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

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

Chemistry Electives

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

Technical Electives

AGB 423 Food and Industrial Microbiology 3
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 the following:

Chemistry Electives

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

Technical Electives

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

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

Chemistry Electives

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

Technical Electives

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

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

Chemistry Electives

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

Technical Electives

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

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

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

Energy Conversion and Conservation

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

Plant Administration and Management

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

Simulation, Control, and Design

CHE 494 Special Topics 1–4
CHE 527 Advanced Applied Mathematical Analysis in Chemical Engineering 3

CHE 528 Process Optimization Techniques 3
CHE 556 Separation Processes 3
CHE 563 Chemical Engineering Design 3

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

Chemistry Elective

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

Technical Electives

CHE 458 Semiconductor Material Processing 3
CHE 494 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

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 *N2* 3
ECE 394 ST: Conservation Principles 4
ECN 111 Macroeconomic Principles *SB* 3
or ECN 112 Microeconomic Principles *SB* (3)
MAT 274 Elementary Differential Equations 3

Total 16

Second Semester

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

Total 17

Third Year

First Semester

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

Total 17

Second Semester

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

Total 18

Fourth Year

First Semester

CHE 442 Chemical Reactor Design 3
CHE 451 Chemical Engineering Laboratory 2
CHE 461 Process Control *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
Total degree requirements: 128

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

BIOENGINEERING—B.S.E.

PROFESSORS
GUILBEAU, TOWE

ASSOCIATE PROFESSORS
GARCIA, HE, PIZZICONI, SWEENEY, YAMAGUCHI

ASSISTANT PROFESSOR
KIPKE

LECTURER
D. BEAUDOIN

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

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

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

DEGREE REQUIREMENTS

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

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

COURSE REQUIREMENTS

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

First-Year Composition

ENG	101, 102	First-Year Composition or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	6
Total			6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

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

Literacy and Critical Inquiry

BME	413	Biomedical Instrumentation *L2*	3
BME	423	Biomedical Instrumentation Laboratory *L2*	1
ECE	300	Intermediate Engineering Design *L1*	3
Total			7

Natural Sciences/Basic Sciences

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

Numeracy/Mathematics

ECE	100	Introduction to Engineering Design *N3*	4
MAT	242	Elementary Linear Algebra or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers I (2)	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
Total			21
General Studies/school requirements total			60

Engineering Core

ECE	210	Engineering Mechanics I: Statics	3
ECE	301	Electrical Networks I	4
ECE	334	Electronic Devices and Instrumentation	4
ECE	340	Thermodynamics	3
ECE	350	Structure and Properties of Materials	3
Total			17

Major

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

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

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

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

Bioengineering Areas of Emphasis

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

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

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

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

Biomaterials Engineering. This area of emphasis integrates the student's knowledge of materials science and engineering with biomaterials science and engineering concepts for the design of materials intended to be used for the development of medical and diagnostic devices. It emphasizes structure-property relationships of engineering materials (metals, polymers, ceramics, and composites) and biological materials, biomaterial-host response phenomena, technical and regulatory aspects of biomaterials testing and evaluation. Students interested in careers in the biomaterials, medical device, or biotechnology industries should 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 or MSE 471 Introduction to Ceramics (3)	3
Total			9

Biomechanical Engineering. This emphasis is designed to strengthen the student's knowledge of mechanics and control theory. Students interested in careers related to biomechanical design, orthotic/prosthetic devices, rehabilitation engineering, and orthopedic implants should consider this area of emphasis. It also provides the fundamentals for the study of neuromuscular control and the study of human motion. The following course is a required selection in the engineering school requirements (page 202):

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

Technical electives must include the following:

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

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

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

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

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

Molecular and Cellular Bioengineering. This emphasis is designed to strengthen and integrate the student's knowledge of molecular and cellular biology, biochemistry, and biomaterials science and engineering for the design of biomolecular and cellular-based hybrid medical and diagnostic devices. It is particularly suited for students interested in pursuing graduate studies in molecular and cellular bioengineering and health-related biotechnology. Technical electives must include the following:

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

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

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

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

Bioengineering Program of Study
Typical Four-Year Sequence

First Year

First Semester

CHM	113	General Chemistry *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

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*[1]	3
PHY	122	University Physics Laboratory I *S1/S2*[1]	1
Total			15

Second Year

First Semester

BIO	181	General Biology *S1/S2*	4
BME	201	Introduction to Bioengineering *L1*	3
ECE	210	Engineering Mechanics I: Statics	3
MAT	272	Calculus with Analytic Geometry III	4
PHY	131	University Physics II: Electricity and Magnetism *S1/S2*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1
Total			18

Second Semester

ECE	301	Electrical Networks I	4
ECE	350	Structure and Properties of Materials	3
MAT	274	Elementary Differential Equations	3
HU, SB, and awareness area courses[3]			6
Total			16

Third Year

First Semester

BME	331	Biomedical Engineering Transport I: Fluids	3
BME	435	Physiology for Engineers	4
ECE	300	Intermediate Engineering Design *L1*	3
ECE	340	Thermodynamics	3
ECN	111	Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3)	3

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

MAT	242	Elementary Linear Algebra or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	2
Total			18

Second Semester

BME	318	Biomaterials	3
BME	334	Bioengineering Heat and Mass Transfer	3
ECE	334	Electronic Devices and Instrumentation	4
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
HU, SB, and awareness area courses[3]			4
Total			17

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 course[3]			3
Technical electives			3
Total			16

Second Semester

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

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

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

3 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 196.

MATERIALS SCIENCE AND ENGINEERING—B.S.E.

REGENTS' PROFESSOR
MAYER

PROFESSORS
DEY, KRAUSE, MAHAJAN

ASSOCIATE PROFESSOR
ADAMS

ASSISTANT PROFESSOR
ALFORD

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

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

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

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

DEGREE REQUIREMENTS

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

Graduation Requirements. In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

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

First-Year Composition

ENG	101, 102	First-Year Composition or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	6
Total			6

General Studies/School Requirements

Humanities and Fine Arts/Social and Behavioral Sciences

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

Literacy and Critical Inquiry

ECE	300	Intermediate Engineering Design *L1*	3
ECE	400	Engineering Communications *L2*	3
Total			6

Natural Sciences/Basic Sciences

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

Numeracy/Mathematics

ECE	100	Introduction to Engineering Design *N3*	4

MAT	242	Elementary Linear Algebra	2
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
Total			21
General Studies/school requirements total			59

Engineering Core

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

Major

ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
MSE	353	Introduction to Materials Processing and Synthesis	3
MSE	354	Experiments in Materials Synthesis and Processing I	2
MSE	355	Introduction to Materials Science and Engineering	3
MSE	420	Physical Metallurgy	3
MSE	421	Physical Metallurgy Laboratory	1
MSE	430	Thermodynamics of Materials	3
MSE	440	Mechanical Properties of Solids	3
MSE	450	X-ray and Electron Diffraction	3
MSE	470	Polymers and Composites	3
MSE	471	Introduction to Ceramics	3
MSE	482	Materials Engineering Design	3
MSE	490	Capstone Design Project	3
Select two of the following four courses[3]			6
CHM	325	Analytical Chemistry (3)	
CHM	331	General Organic Chemistry (3)	
CHM	341	Elementary Physical Chemistry (3)	
PHY	361	Introductory Modern Physics (3)	
Technical electives[4]			8
Total			50

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

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

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

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

Materials Science and Engineering Areas of Emphasis

Technical electives may be selected from one or more of the following areas. A student may, with prior approval of the department, select a general area or a set of courses that would support a career objective not covered by the following categories.

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

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

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

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

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

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

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

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

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

CHE	458	Semiconductor Material Processing	3
MAE	422	Mechanics of Materials	4
MAE	441	Principles of Design	3
MAE	442	Mechanical Systems Design	3
MSE	431	Corrosion and Corrosion Control	3
MSE	441	Analysis of Material Failures	3
MSE	453	Experiments in Materials Synthesis and Processing II	2
MSE	454	Advanced Materials Processing and Synthesis	3
MSE	472	Integrated Circuit Materials Science	3

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

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

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

MAE	351	Manufacturing Processes	3
MSE	431	Corrosion and Corrosion Control	3

MSE	441	Analysis of Material Failures	3
MSE	472	Integrated Circuit Materials Science	3

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

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

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

First Year

First Semester

CHM	113	General Chemistry *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

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* [1]	3
PHY	122	University Physics Laboratory I *S1/S2*[1]	1
Total			15

Second Year

First Semester

ECE	210	Engineering Mechanics I: Statics	3
ECN	111	Macroeconomic Principles *SB*	3
MAT	242	Elementary Linear Algebra	2
MAT	272	Calculus with Analytic Geometry III	4
PHY	131	University Physics II: Electricity and Magnetism *S1/S2*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1
Total			16

Second Semester

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

Third Year

First Semester

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
Advanced science course[4]			3
HU, SB, and awareness area courses[3]			4
Total			16

Second Semester

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

Fourth Year

First Semester

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

Second Semester

ECE	400	Engineering Communications *L2*	3
MSE	490	Capstone Design Project	3
Advanced science course[4]			3
HU, SB, and awareness area course[3]			3
Technical electives			4
Total			16
Degree requirements total			128

---

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

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

3 Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 196.

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

BIOENGINEERING (BME)

BME 201 Introduction to Bioengineering. (3) F
Impact of bioengineering on society. Developing an awareness of the contributions of bioengineering to solve medical and biological problems. Cross-listed as STE 201. Prerequisite: ENG 102 or 105 or 108. *General Studies: L1.*

BME 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, HU.*

BME 318 Biomaterials. (3) S
Material properties of natural and artificial biomaterials. Tissue and blood biocompatibility. Uses of materials to replace body parts. Prerequisite: ECE 350.

BME 331 Biomedical Engineering Transport I: Fluids. (3) F, S
Transport phenomena with emphasis on biomedical engineering fluid systems. Prerequisites: MAT 274; PHY 131.

BME 334 Bioengineering Heat and Mass Transfer. (3) S
Application of the principles of heat and mass transfer phenomena to solution of problems in medicine and medical device design. Prerequisite: ECE 340. Prerequisite with a grade of "C" or higher: BME 331.

BME 350 Signals and Systems for Bioengineers. (3) S
Application of principles of calculus and ordinary differential equations to modeling and analysis of responses, signals, and signal transfers in bio-systems. Prerequisites: ECE 301; MAT 272, 274.

BME 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. Prerequisite with a grade of "C" or higher: BME 334.

BME 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.

BME 413 Biomedical Instrumentation. (3) F
Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems. Prerequisites: ECE 300, 334. Prerequisite with a grade of "C" or higher: BME 435. Corequisite: BME 423. *General Studies: L2.*

BME 415 Biomedical Transport Processes. (3) A
Principles of momentum, heat, and mass transport with applications to medical and biological systems and medical device design. Prerequisites: MAT 274; PHY 131.

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

BME 417 Biomedical Engineering Capstone Design I. (3) F
Technical, regulatory, economic, legal, social, and ethical aspects of medical device systems engineering design. Lecture, field trips. Prerequisites with a grade of "C" or higher: BME 318, 334.

BME 419 Biocontrol Systems. (3) F
Application of linear and nonlinear control systems techniques toward analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body. Prerequisites: ECE 301; MAT 274.

BME 423 Biomedical Instrumentation Laboratory. (1) F
Laboratory experience with problems, concepts, and techniques of biomedical instrumentation in static and dynamic environments. Lab. Prerequisites: ECE 300, 334. Prerequisite with a grade of "C" or higher: BME 435. Corequisite: BME 413. *General Studies: L2.*

BME 435 Physiology for Engineers. (4) F
Physiology of the nervous, muscular, cardiovascular, endocrine, renal, and respiratory systems. Emphasizes use of quantitative methods in understanding physiological systems. Lecture, lab. Prerequisites: BIO 181 and CHM 116 and PHY 131 *or* instructor approval.

BME 470 Microcomputer Applications in Bioengineering. (4) S
Use of microcomputers for real-time data collection, analysis, and control of experiments involving actual and simulated physiological systems. Lecture, lab. Prerequisites: ECE 100, 334. Prerequisite with a grade of "C" or higher: BME 435.

BME 490 Biomedical Engineering Capstone Design II. (1–5) F, S
Individual projects in medical systems or medical device design and development. Lecture, lab. Prerequisite with a grade of "C" or higher: BME 417.

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

BME 511 Biomedical Engineering. (3) A
Diagnostic and prosthetic methods using engineering methodology. Transport, metabolic, and autoregulatory processes in the body.

BME 512 Biomedical Engineering II. (3) A
Electrophysiology and nerve pacing applications, introduction to biomechanics and joint/limb replacement, technology, cardiovascular and pulmonary fluid mechanics, and mathematical modeling.

BME 513 Biomedical Instrumentation I. (3) A
Principles of medical instrumentation. Studies of medical diagnostic instruments and techniques for the measurement of physiologic variables in living systems.

BME 514 Advanced Biomedical Instrumentation. (3) F
Principles of applied biophysical measurements using bioelectric and radiological approach. Prerequisites: ECE 334; MAT 274 (or equivalent).

BME 515 Biomedical Transport Processes. (3) N
Principles of momentum, heat, and mass transport with applications to medical and biological systems and medical device design. Prerequisite: instructor approval.

BME 516 Topics in Biomechanics. (3) F
Mechanical properties of bone, muscle, and soft tissue. Static and dynamic analysis of human movement tasks, including in-depth project. Prerequisite: instructor approval.

BME 518 Introduction to Biomaterials. (3) S
Topics include structure property relationships for synthetic and natural biomaterials, biocompatibility, and uses of materials to replace body parts. Prerequisite: ECE 350 or equivalent or instructor approval.

BME 519 Topics in Biocontrol Systems. (3) F
Linear and nonlinear control systems analysis of neuromusculoskeletal, cardiovascular, thermal, and mass transfer systems of the body, including in-depth project. Prerequisites: ECE 301 and MAT 274 *or* instructor approval.

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

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

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

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

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

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

BME 532 Prosthetic and Rehabilitation Engineering. (3) A
Analysis and critical assessment of design and control strategies for state-of-the-art medical devices used in rehabilitation engineering. Pre- or corequisite: BME 416 or 516 or EPE 610.

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

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

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

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

BME 551 Movement Biomechanics. (3) S
Mechanics applied to the analysis and modeling of physiological movements. Computational modeling of muscles, tendons, joints, and the skeletal system with application to sports and rehabilitation. Prerequisite: BME 416 or 516 or instructor approval.

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

BME 567 Radiation Shielding and Transport. (3) F
Shielding for radiation therapy, diagnostic radiology, cyclotrons, and nuclear reactors. Monte Carlo and empirical computational methods, regulations, and design problems. Cross-listed as EEE 567. Prerequisite: EEE 465.

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

CHEMICAL ENGINEERING (CHE)

CHE 311 Introduction to Chemical Processing. (3) F, S
Application of chemical engineering analysis and problem solving to chemical processes material and energy balance methods and skills. Prerequisites: CHM 116; MAT 271.

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

CHE 331 Transport Phenomena I: Fluids. (3) F, S
Transport phenomena, with emphasis on fluid systems. Prerequisites: CHE 311; ECE 394 ST: Conservation Principles; MAT 274.

CHE 332 Transport Phenomena II: Energy Transfer. (3) F, S
Continuation of transport principles, with emphasis on energy transport in stationary and fluid systems. Prerequisite: CHE 331.

CHE 333 Transport Phenomena III: Mass Transfer. (3) F, S
The application of transport phenomena to mass transfer. The design of mass transfer equipment, including staged processes. Prerequisite: CHE 332.

CHE 342 Applied Chemical Thermodynamics. (4) F, S
Application of conservation and accounting principles with non-ideal property estimation techniques to model phase and chemical equilibrium processes. Lecture, recitation. Prerequisites: CHE 311; ECE 394 ST: Conservation Principles, ECE 394 ST: Properties that Matter. Pre- or corequisite: MAT 272.

CHE 352 Transport Laboratories. (3) S
The demonstration of transport phenomena principles with experiments in fluid flow, heat, and mass transfer. Prerequisites: CHE 332; ECE 300. Pre- or corequisite: CHE 333. *General Studies: L2.*

CHE 432 Principles of Chemical Engineering Design. (3) F
Multicomponent distillation, engineering economics, equipment sizing and costs, plant operation economics, and simulation and optimization techniques. Prerequisites: CHE 332, 342.

CHE 442 Chemical Reactor Design. (3) F, S
Application of kinetics to chemical reactor design. Prerequisite: CHE 342. Pre- or corequisite: CHE 333.

CHE 451 Chemical Engineering Laboratory. (2) F
Operation, control, and design of experimental and industrial process equipment; independent research projects. 6 hours lab. Prerequisites: CHE 333, 352; ECE 384.

CHE 458 Semiconductor Material Processing. (3) N
Introduction to the processing and characterization of electronic materials for semiconductor applications. Prerequisites: CHE 333, 342.

CHE 461 Process Control. (4) F
Process dynamics, instrumentation, and feedback applied to automatic process control. Lecture, lab. Prerequisite: ECE 394 ST: Systems. *General Studies: N3.*

CHE 462 Process Design. (3) S
Application of economic principles to optimize equipment selection and design; development and design of process systems. Prerequisites: CHE 432, 442.

CHE 474 Chemical Engineering Design for the Environment. (3) F
Conflict of processing materials and preserving the natural resources. Students will understand/value the environment and attempt to control our impact. Prerequisites: CHE 333, 342.

CHE 475 Biochemical Engineering. (3) N
Application of chemical engineering methods, mass transfer, thermodynamics, and transport phenomena to industrial biotechnology. Prerequisite: instructor approval.

CHE 476 Bioreaction Engineering. (3) N
Principles of analysis and design of reactors for processing with cells and other biologically active materials; applications of reaction engineering in biotechnology. Prerequisite: instructor approval.

CHE 477 Bioseparation Processes. (3) N
Principles of separation of biologically active chemicals; the application, scaleup, and design of separation processes in biotechnology. Prerequisite: instructor approval.

CHE 478 Industrial Water Quality Engineering. (3) F
Chemical treatment processing, quality criteria and control, system design, and water pollutants. Prerequisites: CHE 331; senior standing.

CHE 479 Air Quality Control. (3) F
Air pollutant control, effects, and origins. Chemical and physical processes, including combustion, control equipment design, dispersion, and sampling. Prerequisites: CHE 331; senior standing.

CHE 490 Chemical Engineering Projects. (1–5) F, S, SS
Individual projects in chemical engineering operations and design. Prerequisite: instructor approval.

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

CHE 501 Introduction to Transport Phenomena. (3) F, S
Transport phenomena, with emphasis on fluid systems. Prerequisite: transition student with instructor approval.

CHE 502 Introduction to Energy Transport. (3) F, S
Continuation of transport principles, with emphasis on energy transport in stationary and fluid systems. Prerequisite: transition student with instructor approval.

CHE 503 Introduction to Mass Transport. (3) F, S
The application of transport phenomena to mass transfer. The design of mass transfer equipment, including staged processes. Prerequisite: transition student with instructor approval.

CHE 504 Introduction to Chemical Thermodynamics. (3) F, S
Energy relations and equilibrium conversions based on chemical potentials and phase equilibria. Prerequisite: transition student with instructor approval.

CHE 505 Introduction to Chemical Reactor Design. (3) F, S
Application of kinetics to chemical reactor design. Prerequisite: transition student with instructor approval.

CHE 527 Advanced Applied Mathematical Analysis in Chemical Engineering. (3) F
Formulation and solution of complex mathematical relationships resulting from the description of physical problems in mass, energy, and momentum transfer and chemical kinetics.

CHE 528 Process Optimization Techniques. (3) S
Method for optimizing engineering processes. Experimental design and analysis; linear and nonlinear regression methods; classical, search, and dynamic programming algorithms.

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

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

CHE 536 Convective Mass Transfer. (3) N
Turbulent flow for multicomponent systems, including chemical reactions with applications in separations and air pollution. Prerequisite: CHE 533 or MAE 571.

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

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

CHE 548 Topics in Catalysis. (3) N
Engineering catalysis, emphasizing adsorption, kinetics, characterization, diffusional considerations, and reactor design. Other topics include mechanisms, surface analyses, and electronic structure.

CHE 552 Industrial Water Quality Engineering. (3) N
Water pollutants, quality criteria and control, chemical treatment processing, and system design. Case studies. Prerequisite: CHE 331 or equivalent.

CHE 553 Air Quality Control. (3) N
Air pollutant origins, effects, and control. Physical and chemical processes, including dispersion, combustion, sampling, control equipment design, and special topics. Prerequisite: CHE 331 or equivalent.

CHE 554 New Energy Technology. (3) N
Gasification, liquefaction pyrolysis, and combustion processes for coal, wastes, and other raw materials. In-situ processes for coal, oil, shale, and geothermal energy. Environmental quality issues.

CHE 556 Separation Processes. (3) N
Topics in binary/multicomponent separation, rate governed and equilibration processes, mass transfer criteria, energy requirements, separating agents and devices, and staged operations.

CHE 558 Electronic Materials. (3) N
Processing and characterization of electronic materials for semiconductor type uses. Thermodynamics and transport phenomena, phase equilibria and structure, mass transfer, and diffusion and thermal properties.

CHE 561 Advanced Process Control. (3) S
Dynamic process representation, linear optimal control, optimal state reconstruction, and parameter and state estimation techniques for continuous and discrete time systems.

CHE 563 Chemical Engineering Design. (3) N
Computational methods; the design of chemical plants and processes.

MATERIALS SCIENCE AND ENGINEERING (MSE)

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

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

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

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

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

MSE 430 Thermodynamics of Materials. (3) 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.

MSE 431 Corrosion and Corrosion Control. (3) S
Introduction to corrosion mechanisms and methods of preventing corrosion. Topics include the following: electrochemistry, polarization, corrosion rates, oxidation, coatings, and cathodic protection. Prerequisite: ECE 350.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MSE 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.

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

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

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

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

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

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

MSE 530 Materials Thermodynamics and Kinetics. (3) S
Thermodynamics of alloy systems, diffusion in solids, kinetics of precipitation, and phase transformations in solids. Prerequisites: ECE 340, 350.

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

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

Sean Dengler demonstrates equipment in the Integrated Manufacturing Engineering Laboratory. Created by partnerships between the university and the high-tech industry, the lab offers students practical experience in engineering and manufacturing.

Tim Trumble photo

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

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

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

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

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

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

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

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

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

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