

College of Engineering

The mission of the Marquette University College of Engineering is to prepare undergraduate and graduate students for successful careers based on a strong ethical and moral foundation, to advance the state of the art in engineering, to serve the professional and technical communities and to contribute to our global society.

These statements reflect the essential nature of the college. The motivation of the college centers about its desire to emphasize to the engineering community the intrinsic value of humankind and of the individuals who comprise it. This motivation flows directly from the fact that the college is an integral part of a Catholic, Jesuit university.

DEGREES OFFERED

Marquette University confers the degree of bachelor of science in biomedical, civil, computer, electrical or mechanical engineering on those students who have satisfactorily completed one of the prescribed curricula in the majors within the departments of Biomedical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical Engineering. Engineering students have the opportunity to earn a minor in another engineering field as well as in many other non-engineering areas.

The master of science degree is conferred upon recommendation by the Graduate School for candidates in biomedical, civil, electrical and computer, and mechanical engineering, and for candidates in health care technologies management. The master of engineering (M.E.) degree is conferred for candidates in biomedical engineering, the master of science in engineering management (M.S.E.M.) degree is conferred for candidates in engineering management, and the doctoral degree is conferred for candidates in biomedical, civil, electrical and computer, and mechanical engineering. Five certificates are offered in civil engineering and four certificates are offered in electrical engineering. Details on the master's, doctoral and certificate programs are contained in the *Graduate Bulletin*.

MAJORS OFFERED

The College of Engineering is made up of four departments which offer the following majors: the Department of Biomedical Engineering with majors in biocomputing, bioelectronics and biomechanics; the Department of Civil and Environmental Engineering with majors in civil engineering, environmental engineering and construction engineering and management; the Department of Electrical and Computer Engineering with majors in computer engineering, electrical and electronic engineering, and electrical and computer engineering; the Department of Mechanical Engineering with a major in mechanical engineering.

ACCREDITATION

The College of Engineering is a member of the American Society for Engineering Education. The biomedical, civil, computer, electrical and mechanical engineering programs are accredited by the Engineering Accreditation Commission of ABET; 111 Market Place, Suite 1050; Baltimore, MD 21202-4012; telephone: (410) 347-7700.

The construction engineering and management program is eligible for accreditation after its first graduating class.

ADMISSION REQUIREMENTS

Freshman Admission: Freshman applicants to the College of Engineering are expected to fulfill the admission requirements listed in the University section of this bulletin.

Admission with Advanced Standing: Applicants who have been enrolled or registered in an institution of higher learning since high school graduation, including Marquette University, need a minimum grade average of 2.500 (based on a four-point system) in previous college work as a minimum of consideration. An applicant's entire academic performance will be evaluated in making an admission decision.

ADVANCED STANDING

The College of Engineering maintains formal agreements with various colleges for student transfer into selected engineering degree programs and for the transfer of advanced standing credits. The following institutions have engaged the College of Engineering to develop a structure for either 2+2, Pre-engineering or Dual Degree arrangements.

Fox Valley Technical College, Appleton, Wisconsin	2+3 Program
Waukesha County Technical College, Waukesha, Wisconsin	2+2 Program
Gateway Technical College, Racine, Wisconsin	2+3 Program
Creighton University, Omaha, Nebraska	Pre-engineering
Spring Hill College, Mobile, Alabama	Dual Degree Program

For more information contact the office of the associate dean for academic affairs.

GRADUATION REQUIREMENTS

The degree bachelor of science in biomedical, civil, computer, electrical or mechanical engineering may be conferred on students who successfully complete a curriculum as prescribed for the degree, and who have satisfied the following requirements:

- A minimum of 32 hours of upper division course work must be completed at Marquette University. At least 15 hours must be either within the major or the required department courses shown in the senior year of the catalog showcase curriculum.
- A cumulative C average or better in Marquette work.
- A cumulative grade average of C or better in all engineering courses.
- A minimum of the number of semester hours required for the major.
- The completion of all required courses.
- Formal application for a degree filed in the office of the associate dean for academic affairs no later than two weeks after the beginning of the candidate's last term.

GENERAL DEGREE REQUIREMENTS

All candidates for a baccalaureate degree in engineering must complete requirements for one of the majors on the following pages:

Department of Biomedical Engineering

Biocomputing
Bioelectronics
Biomechanics

Department of Civil and Environmental Engineering

Civil Engineering
Construction Engineering and Management
Environmental Engineering

Department of Electrical and Computer Engineering
 Computer Engineering
 Electrical and Computer Engineering
 Electrical and Electronic Engineering
 Department of Mechanical Engineering
 Mechanical Engineering

UNIVERSITY CORE OF COMMON STUDIES (UCCS) AND COLLEGE OF ENGINEERING CURRICULAR REQUIREMENTS

The College of Engineering curricula amplify and deepen the University Core of Common Studies (UCCS) requirements which are fully described in the bulletin section titled “The University Core of Common Studies.”

The implementation of the UCCS within each major is explicitly detailed in each department’s bulletin section. The following footnotes are referenced in the curriculum for each of the various majors:

- b University Core course
- c The Core Electives must satisfy University Core Requirements in the following four Knowledge Areas: Diverse Cultures, Histories of Cultures and Societies, Individual and Social Behavior, and Literature/Performing Arts. See section on University Core of Common Studies for lists of acceptable courses.
- d If the previous Core Electives span all four Knowledge Areas (as listed in the previous footnote), a three-credit free elective may be chosen. This situation may exist if one of the student’s core electives is a “dual-application” core course, as described in the section on the University Core of Common Studies.
- e The Theology Elective must be selected from the list of acceptable Core courses in the Theology Knowledge Area. See section on University Core of Common Studies.
- f The Core Rhetoric Knowledge Area is satisfied by ENGL 1001, and ENGL 1002 or COMM 1100.

Courses which satisfy both the UCCS and the College of Engineering curricula are outlined below:

Rhetoric (R)	6 credits
ENGL 1001, and ENGL 1002 or COMM 1100	
Mathematical Reasoning (MR)	4-8 credits
MATH 1450	
Individual and Social Behavior (ISB)	3 credits
All UCCS courses	
Diverse Cultures (DC)	3 credits
All UCCS courses	
Literature/Performing Arts (LPA)	3 credits
All UCCS courses	
Histories of Cultures and Societies (HCS)	3 credits
All UCCS courses	
Science and Nature (SN)	12 credits
CHEM 1001, PHYS 1003, PHYS 1004	
Human Nature and Ethics (HNE)	6 credits
PHIL 1001, PHIL 2310	
Theology (T)	6 credits
THEO 1001, Theology Elective	

New courses are approved for the UCCS each semester. For a regularly updated list of approved Core courses, please consult the Core of Common Studies Web site at www.marquette.edu/programs/core.

ACADEMIC REGULATIONS

Students in the College of Engineering are expected to comply with the academic requirements and regulations listed in the University section of this bulletin, along with all official college regulations. For College of Engineering policies, please refer to our Web site at www.marquette.edu/engineering/pages/AllYouNeed/academicpolicies.html.

ACADEMIC HONESTY

The College of Engineering recognizes that any form or degree of academic dishonesty challenges the principles of truth and honesty which are among the most important foundation principles of Marquette University. Consequently, the college treats matters of academic dishonesty as serious violations of academic trust and penalizes all students found to engage in such behavior. The reduction of academic dishonesty within the College of Engineering must be a cooperative enterprise of faculty, student and administrators.

Refer to the University Academic Honesty Policy and Procedures in the front section of this bulletin.

ATTENDANCE

A. Because absence from class will prevent a student from getting the full benefit of a course, and because in many courses each student's involvement contributes to the learning process for all other students in the class, attendance is mandatory for every exercise of a course in which a student is registered. Excessive absences may result in lower grades, or being withdrawn from a class for reason of absences with a WA grade.

B. Students registered in any course offered by the College of Engineering are bound by this attendance policy even if they are enrolled in another college, program, or division of the university. It is the responsibility of each student to know and follow the college's class attendance policy and any specific attendance regulations of his/her instructors.

C. In the case of an emergency absence (prolonged absence from class due to illness or other personal emergency), a student must inform the office of the associate dean for academic affairs, which will keep a written record of such cases and inform the relevant instructors. Normally, the college office will not keep a record nor take any action unless such absences extend for one week or longer. For a full description of this and other College of Engineering policies, please refer to our Web site at www.marquette.edu/engineering/pages/AllYouNeed/academicpolicies.html.

ACADEMIC LOAD

The academic load of a student is measured by credit hours assigned to each course. The normal engineering program varies from 15 to 19 credit hours per term.

Request for permission to exceed 20 credit hours must be submitted for approval prior to registration to the associate dean for academic affairs on forms available on the Office of the Registrar Web site, www.marquette.edu/registrar/policies.

OTHER ACADEMIC POLICIES

For a complete list of all College of Engineering academic policies, please refer to our Web site at www.marquette.edu/engineering/pages/AllYouNeed/academicpolicies.html.

SPECIAL ACADEMIC PROGRAMS

THE COOPERATIVE EDUCATION PROGRAM

The Cooperative Education Program is an organized program integrating classroom work and practical work experience. Students in this program alternate periods of attendance at college with periods of employment in industry. The employment constitutes a regular, continuing, and desirable element in the educational process. It is related to some phase of the field of study in which the student is engaged and should be diversified to afford a range of experience. The objective is balanced training; the combination of theory and practical work experience during the early years of professional development. The Engineering Cooperative Education Program (Co-op program) has been employed successfully at Marquette since 1919.

At Marquette, all students spend the first two years in the conventional academic program. Those not electing to participate in the Co-op Program continue through their last two years on the same conventional program. Admission to the Co-op Program is conditioned by: 1) the applicant's academic standing; 2) his/her general employability, possibly including United States citizenship; and 3) the number of openings made available by industry. It should therefore be regarded as a privilege to be sought after, one usually gained only by those best qualified.

Early in the sophomore year, students attend an engineering orientation class, GEEN 2952, to learn about the Co-op Program's policies and procedures and the placement process. They

then apply to the Co-op Program and pursue co-op placement by submitting resumes and interviewing with prospective employers. Students who are hired by co-op employers begin working during the summer or fall following completion of their sophomore year, or soon thereafter. The students participating in the Co-op Program are divided into three groups which alternate between school and work on a planned basis. Typically, more than 230 students are in the Co-op Program at any given time and they are employed with more than 100 cooperating employers located in the Midwest and throughout the country.

NORMAL CO-OP SCHEDULE

Freshman		Sophomore			Co-op Section	Junior			Pre-Senior			Senior			Approx. Total Work
Fa	Sp	Su	Fa	Sp		Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	
S	S	V	S	S	A	S	W	S	W	S	W	S	W	S	16 mos.
S	S	V	S	S	B	W	S	W	S	W	S	W	S	S	15 mos.
S	S	V	S	S	C	V	S	W	S	W	S	W	S	S	12 mos.

S=School V=Vacation W=Work Period

The approved training programs provide for rapid progress of the Co-op student through the various phases of the firm's engineering processes, according to a planned schedule. The Co-op Program therefore gives the students an opportunity to combine their classroom learning with practical experience, it provides financial assistance to pay their education expenses, and it provides an orientation to both the world of work and career opportunities available. For the employers, the Co-op Program provides a ready-made training and recruitment program, it provides a good source of technical labor, and it promotes college relations.

Since the cooperative education program is considered an integral part of a student's education, the Co-op student is a full-time student at Marquette University; whether he/she is in school or at work. When the Co-op student is at work, he/she is under the company's direct supervision. The student is subject to the rules of the company which may include background checks and/or drug screening. Wages are paid directly to the student. The university does not employ the student but cooperates with industry in arranging such employment. The Co-op Program provides one credit hour for each work period successfully completed. The Co-op student is required to follow an especially arranged *Schedule of Classes* while in school so as to accommodate his/her alternating status (in school, at work, etc.) and assure that sequential courses are scheduled in proper order. This includes summer sessions as noted on the Normal Co-op Schedule. Registration for each work period is required of *all* Co-ops, and credit is established and graded through enrollment in the appropriate Co-op Grading Period during the following school period. Three credit hours earned via Co-op work experience may be applied to Bachelor of Science degree requirements as a substitute for one technical elective course.

THE NOYCE SCHOLAR TEACHING COOPERATIVE EDUCATION PROGRAM

The national demand for teachers of science, technology, and math (STEM) continues to grow. This program prepares interested undergraduates to become licensed teachers who can help meet the STEM-related needs of our increasingly global society through the effective education of middle and high school students.

The Noyce Scholar Program is based on an adaptation of the cooperative education model that has successfully prepared Marquette University engineers for 90 years into a similar program of preparation for engineering and science students desiring to become STEM teachers. Through this uniquely adapted cooperative education model, intensive field experiences in education (i.e., teaching co-ops) are integrated with classroom instruction to meet the Wisconsin state standards for STEM teacher licensure. This program allows engineering students to complete their engineering and STEM teaching degree requirements in 5 years, and may be customized for any of the engineering majors. The approved STEM majors for Wisconsin teaching certification include: biology, broad field science, chemistry, physics, and mathematics.

*TEACHING CO-OP SCHEDULE:***Sophomore**

Spring EDUC 1210 plus engineering course work
 Summer EDUC 1220 (middle school)

Junior

Fall Teaching Co-op #1 (high school); EDUC 2037; EDUC 2227; EDUC 4217
 Spring Engineering and STEM course work
 Summer Project Based Learning Experience

Pre-senior

Fall Engineering and STEM course work
 Spring Teaching Co-op #2 (middle school); EDUC 4017 or MATH 3030; EDUC 4297
 Summer Engineering and STEM course work (as needed)

Senior

Fall Teaching Co-op #3 (middle or high school); EDUC 4965
 Spring Engineering and STEM course work

Specific degree requirements for the secondary middle/secondary education and STEM teaching majors include:

- EDUC 1210 (meets UCCS Diverse Cultures), EDUC 1220, EDUC 2037, EDUC 2227, EDUC 4017 or MATH 3030, EDUC 4217, EDUC 4297, and EDUC 4965 — these degree requirements are addressed during the aforementioned teaching co-op experiences.
- Biology: see Major in Biology for the Professions
- Broad Field Science: see College of Education, Broad Field Science Major with Teaching Minors in Biology, Chemistry or Physics
- Chemistry: see Major in Chemistry for the Professions
- Physics: see Major in Physics
- Mathematics: see Major in Mathematics

Students must also complete HIST 1001 or HIST 1002 (meets UCCS Histories of Cultures and Societies) and any approved UCCS Literature and Performing Arts literature course.

For more information, see www.marquette.edu/engineering/pages/AllYouNeed/stemcoop.html.

MINOR IN ENGINEERING ETHICS AND VALUES (ENEV)

The goal of this program is to involve engineering students in an elective program which will help them to: (a) understand the impact of Christian, Catholic and Jesuit values on engineering ethics, (b) recognize current engineering ethical issues and (c) strengthen their moral resolve to act courageously on these issues once they enter the engineering profession.

The minor in engineering ethics and values requires 22 credit hours. Requirements include: PHIL 1001, PHIL 2310, and THEO 1001. Students are also required to participate in four 1-credit ENEV colloquia (ENEV 1952, 2952, 3952, 4952). Final course requirements include: 3 credit hours from the following list of courses: BIEN 4931 (selected sections only), CEEN 3770, 4740 and 6 additional credit hours from PHIL 3350, 3740, 4320, 4330, 4335, SOCI 3520, 5400, SOJW 1001, THEO 2400, 4430, 4440, 4450, MANA 3002, BIEN 4931 (selected sections only), CEEN 3720, 4740.

For more information, see the associate dean for academic affairs or www.marquette.edu/engineering/pages/AllYouNeed/enethicsvaluesminor.html.

CONCENTRATION IN ENGINEERING SERVICE

The goal of this program is to provide an integrated opportunity for involvement in engineering-related service learning and reflection throughout the student's undergraduate studies. These experiences also provide an awareness of an engineer's professional responsibilities to the community at large, and future opportunities for such involvement at the local, national and/or international levels.

All engineering undergraduates in good standing are eligible to participate in this program. Students who wish to pursue this concentration should work closely with their academic advisor beginning in their freshman year to effectively integrate their interests and these experiences with their engineering degree requirements.

This concentration requires completion of a minimum of 12 credits including:

1. Local service via service learning in University Core of Common Studies: 3 credits (HEAL 1025 or SOWJ 1001 or PHYS 1003 or PSYC 3210)
2. Engineering service: 6 credits (CEEN 3720 and CEEN 4740)
3. International experience: full-time study abroad (GEEN 9052)

4. International or domestic engineering service project: 3 credits (GEEN 4995 or (BIEN/COEN/CEEN/EECE/MEEN 4997)
5. Engineering service seminar: 0 credits (GEEN 2970)

Completion of these requirements will result in formal recognition of the Engineering Service Concentration on the student's transcript.

For more information, see (www.marquette.edu/engineering/pages/AllYouNeed/engineering-service.html)

CONCENTRATION IN GLOBAL ENGINEERING

The profession of engineering is becoming increasingly global, including geographically distributed design teams, multinational companies and operations, global customer bases and markets, regional and international standards, culturally influenced approaches to research and development, and a world-view of the environment. As a result, there is a need for students to develop a global perspective of their technical field and profession.

The goal of this program is to provide an integrated opportunity for students to experience engineering from a global perspective throughout their studies, and provide formal recognition of these accomplishments via the completion of a concentration as noted on their transcript.

All engineering undergraduates in good standing are eligible to participate in this program. Students who wish to pursue this concentration should work closely with their academic advisor beginning in their freshman year to effectively integrate their interests and these experiences with their engineering degree requirements.

This concentration requires completion of a minimum of 13 credits including:

1. Culture/foreign language: 3 credits (HIST 1301 or HIST 1401 or SPAN 3002)
2. Study abroad experience: 3 credits (ARSC 1005 and ARSC 3005, GEEN 9052 [full-time])
3. International engineering project: full-time (GEEN 4995 or BIEN/COEN/CEEN/EECE/MEEN 4997)
4. international engineering co-op /internship experience or international engineering service or research project: 1-3 credits (BIEN/CEEN/COEN/EECE/MEEN 4993 and 4994; or GEEN 4995)

For more information, see (www.marquette.edu/engineering/pages/AllYouNeed/global-engineering.html)

PART-TIME STUDIES

See the section on the Part-time Studies Program in the front part of this bulletin for information.

STUDY ABROAD PROGRAMS

Engineering students may study abroad with a Marquette affiliated program, a Marquette exchange program, a Marquette summer or intercession program or a non-Marquette program. Students are urged to contact the office of the associate dean for academic affairs as early as possible for details. See also, this bulletin under Study Abroad Programs. The Office of International Education Study Abroad Resource Center is located in the Alumni Memorial Union, 425. For additional information, see www.marquette.edu/abroad. Also see Concentration in Global Engineering above.

FIVE-YEAR COMBINED BS/MS PROGRAMS

Each of the departments in the College of Engineering at Marquette University offers programs which allow highly qualified students to complete a bachelor of science and master of science degree in five calendar years (six years for students enrolled in the Cooperative Education Program). By increasing course loads slightly in the junior year and/or by taking courses in the summer of the junior and/or senior years, qualified students may be able to complete the BS degree on schedule in four years and the MS degree at the end of five calendar years.

Students intending to pursue one of these programs should begin planning at the end of the sophomore year. Formal application to the program takes place during the second term of the junior year. See individual departments for details.

STUDENT ORGANIZATIONS

COLLEGE ORGANIZATIONS

Engineering students are eligible for membership in the Engineering Student Council, composed of the elected officers of the Engineering Association and one member of the governing board of each activity, fraternal, honorary, and professional organization within the College of Engineering.

PROFESSIONAL SOCIETIES

Student chapters have been established by the American Society of Civil Engineers, the Institute of Electrical and Electronics Engineers, the American Society of Mechanical Engineers, Association of Computing Machinery, the Society of Automotive Engineers, National Society of Black Engineers, Engineers Without Borders, the Society of Hispanic Professional Engineers, the Society of Women Engineers, the Institute of Transportation Engineers, American Society for Quality Control, the Biomedical Engineering Society, the Solar Energy Society, and the Society of Manufacturing Engineers.

PROFESSIONAL FRATERNITIES/SORORITIES

Students in the College of Engineering are eligible to join the following professional fraternities on campus: Sigma Phi Delta, international professional engineering fraternity; Triangle, national fraternity for engineers, architects, and scientists; Alpha Omega Epsilon, professional engineering sorority; and Engineering Knights of St. Patrick.

HONOR SOCIETIES

Engineering students are eligible for membership in the following engineering honor societies: Tau Beta Pi, all-engineering; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Pi Tau Sigma, mechanical engineering; Alpha Eta Mu Beta, biomedical engineering; and Upsilon Pi Epsilon, computer engineering. Each year, these societies award membership keys to men and women exhibiting high promise of success.

BACKGROUND CHECKS, DRUG TESTING

Some degrees, majors and/or courses may require a student to submit to a criminal background check and/or drug testing. The results of those checks and/or tests may affect the student's eligibility to continue in that degree, major and/or course.

CURRICULA INFORMATION

DEPARTMENT OF BIOMEDICAL ENGINEERING

The Department of Biomedical Engineering offers curricula that leads to a bachelor of science degree in biomedical engineering.

MISSION

The Department of Biomedical Engineering is a dedicated team committed to the Jesuit tradition of the pursuit of truth. We develop leaders and problem solvers skilled at applying engineering, science and design principles to improve health in the service of humanity by:

- Discovering and disseminating new knowledge;
- Providing excellent undergraduate and graduate education;
- Promoting critical thinking and lifelong learning;
- Guiding students to meaningful and ethical professional and personal lives;
- Fostering interdisciplinary and collaborative research and education through academic and industrial alliances;
- Continuing innovative leadership in education, research and industrial relationships; and
- Inspiring faculty and students to serve others.

Studies in biomedical engineering incorporate courses in biology, chemistry, mathematics, computing and engineering. These courses, in combination, emphasize the interdisciplinary elements of biomedical engineering not presently offered in the more traditional departments of engineering. A solid foundation in the mathematical, physical, and life sciences is necessary for the engineer to function effectively in a medically or biologically oriented problem solving environment. In this environment, the engineer needs to be able to communicate with physicians, to describe and model complex biological systems, to collect and analyze experimental or clinical data, to understand the capabilities and limitations of sophisticated instrumentation, and to understand the principles of design.

There are three majors in the biomedical engineering curriculum: biocomputing, bioelectronics and biomechanics. The bioelectronics major includes rigorous training in electrical engineering within the interdisciplinary framework of the curriculum. Such training, which includes courses in electric circuits and analog and digital electronics, supports interests focused on the measurement of bioelectric signals and biomedical instrumentation design. In the senior year, the culmination of the training features intensive biomedical instrument design and computer laboratories emphasizing modern bioelectric applications. In addition, a senior year capstone design course sequence places the student in a multidisciplinary design team situation to solve an actual industrial bioelectronic design problem.

The biomechanics major includes rigorous training in mechanical engineering within the interdisciplinary framework of the curriculum. Such training, which includes courses in materials and solid mechanics, supports interests focused on the application of biomechanics and biomaterials. In the senior year, the culmination of the training features intensive biomedical instrument design and computer laboratories emphasizing modern biomechanical applications. In addition, a senior-year capstone design course sequence places the student in a multidisciplinary design team situation to solve an actual industrial biomechanical or biomaterial design problem.

The biocomputer engineering curriculum integrates computer engineering and the life sciences, with a solid foundation in mathematics, physics, chemistry and engineering methods. The new curriculum combines foundational computer engineering knowledge with biocomputer engineering applications, integrating biology, physiology, medicine, biomedical software design, biosignal processing, bioinstrumentation. In the senior year, the training culminates with a comprehensive, biocomputer engineering, design laboratory experience that incorporates engineers from industry and emphasizes medical device design and methods for biomedical informatics. In addition, a senior capstone design course places students in a multidisciplinary team working with industry to solve biocomputer design problems.

All majors in biomedical engineering have been designed to be compatible with other programs offered by the College of Engineering. Each major fulfills the requirements of the University Core of Common Studies. The biomechanical and bioelectronics majors require 134 credits for graduation. The biocomputing major requires 135 credits for graduation. Students can earn an optional minor in either electrical or mechanical engineering as well as biology, chemistry, business administration, and others. In addition, the majors retain many of the core courses of the initial two years, and allow the student to elect the co-op/internship program. Since the majors satisfy the entrance requirements of many professional schools, the student can, usually without additional preparation, pursue studies in medical school, dental school, schools of veterinary medicine, law school and graduate schools in biomedical engineering or traditional areas of engineering.

The Department of Biomedical Engineering operates biomedical image and signal processing laboratories, biocomputer, bioelectronic and biomechanical design laboratories, and students have access to computer, electrical and mechanical engineering laboratories as well as the college and university computer facilities. In addition, collaborative programs exist between Marquette University, the Medical College of Wisconsin, the Milwaukee County Medical Complex, Froedtert Memorial Lutheran Hospital, and the Zablocki Veterans Administration Medical Center. These proximate collaborative research programs, some active for three decades, provide a uniquely enhanced laboratory experience that has significantly contributed to the success of biomedical engineering at Marquette.

THE LES ASPIN BIOMEDICAL INTERNSHIPS

The Department of Biomedical Engineering in conjunction with the Les Aspin Center for Government at Marquette University offer internships in medical regulatory and public policy issues. The Les Aspin Biomedical Engineering Internships began in Spring 1997 with qualified biomedical engineering undergraduates traveling to Washington, D.C. The venue for the engi-

neering internships is Capitol Hill, the Food and Drug Administration or private industry located in the Washington, D.C., area. In addition to participating in the internship experience, the students take Marquette University classes at the Les Aspin Center for Government, located a few blocks from Capitol Hill, and reside nearby in Marquette-owned, furnished apartments. This program is unique in providing undergraduate experience in research and regulatory issues.

BIOMEDICAL ENGINEERING COOPERATIVE EDUCATION AND INTERNSHIP PROGRAM

The Biomedical Engineering Co-op/Internship program offers students the opportunity to gain meaningful practical and professional experiences in the health care industrial environment, in addition to their on-campus educational experiences. The undergraduate biomedical program also provides real-world biomedical engineering experiences in the freshman biomedical engineering methods course and Career Development Workshops during the sophomore year. Currently more than 70 percent of the biomedical engineering students participate in co-op or internship opportunities.

Marquette University began its Engineering Co-op Program in 1919. Students usually enter the Co-op program at the end of their sophomore year and complete three to four terms of off-campus employment. The employment experience is alternated with terms of on-campus study, only extending graduation by one year. The College of Engineering is a member of the American Society for Engineering Education and all of its biomedical, civil, computer, electrical and mechanical undergraduate degree programs are accredited by the Engineering Accreditation Commission of the Accreditation Board of ABET; 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: (410) 347-7700. The Construction Engineering and Management program is eligible for accreditation review after its first class graduated. In addition to the formal Co-op program, undergraduates may also gain experience through summer internships.

FIVE YEAR B.S./M.S. PROGRAM

This program allows students to receive a bachelor of science degree and a master of science degree in biomedical engineering in five years. Students with grade point averages (3.500 or above) apply to the program during their junior year. They begin their thesis research the summer between their junior and senior years. Their research laboratory experience continues the summer between their senior and fifth years and throughout their fifth year, culminating in the preparation of a written thesis and defense.

EDUCATIONAL OBJECTIVES

To provide an educational program that will prepare graduates to:

- Participate as a technical contributor and member of a design and/or development team.
- Communicate effectively with individuals and teams with a wide variety of backgrounds.
- Pursue professional or graduate degrees or employment in the biomedical industry.
- Understand the legal, ethical, economic and regulatory requirements of medical device design and biomedical engineering research.
- Define, solve and implement solutions to a problem.
- Progress in developing leadership skills.
- Identify limitations in their own knowledge base and skills and engage in life long learning.

BIOCOMPUTING MAJOR

<i>Freshman</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 1100	2	BIEN 1110	2
BIOL 1001 ^b	3	BIOL 1002	3
MATH 1450 ^{2, b}	4	MATH 1455	4
PHYS 1003 ^b	4	PHYS 1004 ^b	4
Core Rhetoric I ^f	3	EECE 1610	3
	16		16
<i>Sophomore</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2710	3	COEN 2610	3
MATH 2455	3	Core Rhetoric 2 ^f	3
GEEN 2952	0	BIEN 2300	4
CHEM 1001 ^b	4	BIOL 2001	3
BIEN 1120	2	CHEM 1002 ^b	4
BIEN 2100	1		
Core elective ^c	3		
	16		17
<i>Junior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2030	4	BIEN elective ¹	3
BIEN 3300	3	COEN 4710	3
BIEN 4700	3	COEN 4820	3
BIEN elective ¹	3	BIEN 4220	3
COSC 2010	3	BIEN 3200	3
		Core elective ^c	3
	16		18
<i>Senior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 4920	3	BIEN 4998	3
BIEN 3310	3	BIEN 4320	3
BIEN 4280	3	BIEN 4290	3
Core elective ^c	3	BIEN elective ¹	3
PHIL 1001 ^b	3	PHIL 2310 ^b	3
THEO 1001 ^b	3	THEO elective ^e	3
	18		18

Total Credit Hours: 135

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1. Biomedical Engineering Electives — The following is a list of electives typically taken by biomedical engineering students.

This list is not inclusive. Other possible electives include upper division courses in MATH, BIOL, PHYS, CHEM, EECE, MEEN, COEN and related subject areas. These courses can be taken if approved by the adviser, department chair and associate dean through a course substitution form. Medical school bound students are strongly encouraged to take CHEM 2111, CHEM 2112 and BIOL 4101 as electives. BIEN 4931, BIEN 4710, BIEN 4410, BIEN 4230, BIEN 4600, BIEN 4610, BIEN 4630, BIEN 4420, BIEN 4500, BIEN 4720, BIEN 4510, BIEN 4995 (GPA>3.0), EECE 3110, EECE 3120, EECE 3025 (2 cr.), EECE 3035 (2cr.), EECE 4620, CEEN 2130, MEEN 3310, MEEN 3330, MEEN 3250, MEEN 4240, MEEN 4420, COEN 2710, COEN 4810, COEN 4650, BIOL 4101, BIOL 3702, CHEM 2111, CHEM 2112, MATH 2450, or MATH 4630.

2. Students who place out of MATH 1450 through advanced placement are encouraged to take MATH 1451 and MATH 2450 in place of MATH 1450 and MATH 1455.

Note: The three Core electives^c specified in this program assume that one of these Core electives is a Dual Application core course.

If a Dual Application Core elective is not taken, an additional Core elective is required and the total credit hours increases to 138.

BIOELECTRONICS MAJOR**Freshman**

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 1100	2	BIEN 1110	2
BIOL 1001 ^b	3	BIOL 1002	3
MATH 1450 ^{2, b}	4	MATH 1455	4
PHYS 1003 ^b	4	PHYS 1004 ^b	4
Core Rhetoric 1 ^f	3	Core Rhetoric 2 ^f	3
	16		16

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2010	3	EECE 3010	3
EECE 2015	1	ELEN 2020	3
BIEN 1120	2	EECE 2035	1
MATH 2455	3	BIEN 2100	1
GEEN 2952	0	BIOL 2001	3
CHEM 1001 ^b	4	CHEM 1002 ^b	4
Core elective ^c	3	Core elective ^c	3
	16		18

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2030	4	ELEN 3030	4
CEEN 2122	4	BIEN 3310	3
BIEN 3300	3	BIEN 3200	3
BIEN 4700	3	BIEN elective ¹	3
BIEN elective ¹	3	THEO 1001 ^b	3
	17		16

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 4920	3	BIEN 4998	3
BIEN 4320	3	BIEN 4400	3
BIEN 4380	3	BIEN 4390	3
BIEN elective ¹	3	EECE 3015	2
THEO elective ^c	3	PHIL 2310 ^b	3
PHIL 1001 ^b	3	Core elective ^c	3
	18		17

Total Credit Hours: 134

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1. Biomedical Engineering Electives — The following is a list of electives typically taken by biomedical engineering students. This list is not inclusive. Other possible electives include upper division courses in MATH, BIOL, PHYS, CHEM, EECE, MEEN, COEN and related subject areas. These courses can be taken if approved by the adviser, department chair and associate dean through a course substitution form. Medical school bound students are strongly encouraged to take CHEM 2111, CHEM 2112 and BIOL 4101 as electives. BIEN 4931, BIEN 4710, BIEN 4410, BIEN 4230, BIEN 4600, BIEN 4610, BIEN 4630, BIEN 4420, BIEN 4500, BIEN 4720, BIEN 4510, BIEN 4995 (GPA>3.0), EECE 3110, EECE 3120, EECE 3025 (2 cr.), EECE 3035 (2 cr.), EECE 4620, CEEN 2130, MEEN 3310, MEEN 3330, MEEN 3250, MEEN 4240, MEEN 4420, COEN 2710, COEN 4810, COEN 4650, BIOL 4101, BIOL 3702, CHEM 2111, CHEM 2112, MATH 2450, or MATH 4630.

2. Students who place out of MATH 1450 through advanced placement are encouraged to take MATH 1451 and MATH 2450 in place of MATH 1450 and MATH 1455.

Note: The three Core electives^c specified in this program assume that one of these Core electives is a Dual Application core course. If a Dual Application Core elective is not taken, an additional Core elective is required and the total credit hours increases to 137.

BIOMECHANICS MAJOR

<i>Freshman</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 1100	2	BIEN 1110	2
BIOL 1001 ^b	3	BIOL 1002	3
MATH 1450 ^{2, b}	4	MATH 1455	4
PHYS 1003 ^b	4	PHYS 1004 ^b	4
Core Rhetoric 1 ^f	3	Core Rhetoric 2 ^f	3
	16		16
<i>Sophomore</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIOL 2001	3	MEEN 2460	3
CHEM 1001 ^b	4	CHEM 1002 ^b	4
CEEN 2110	3	MEEN 2120	3
MATH 2455	3	BIEN 2100	1
GEEN 2952	0	BIEN 2300	4
BIEN 1120	2	Core elective ^c	3
	15		18
<i>Junior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 3300	3	BIEN 3310	3
CEEN 2130	3	BIEN 4700	3
MEEN 3310	3	BIEN 3200	3
MEEN elective ³	3	BIEN elective ¹	3
THEO 1001 ^b	3	PHIL 1001 ^b	3
Core elective ^c	3	Core elective ^c	3
	18		18
<i>Senior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
BIEN 4920	3	BIEN 4998	3
BIEN 4320	3	BIEN 4400	3
BIEN 4480	3	BIEN 4490	3
BIEN elective ¹	3	BIEN elective ¹	3
MEEN elective ³	3	THEO elective ^c	3
	15	PHIL 2310 ^b	3
			18
Total Credit Hours:			134

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1. Biomedical Engineering Electives — The following is a list of electives typically taken by biomedical engineering students.

This list is not inclusive. Other possible electives include upper division courses in MATH, BIOL, PHYS, CHEM, EECE, MEEN, COEN and related subject areas. These courses can be taken if approved by the adviser, department chair and associate dean through a course substitution form. Medical school bound students are strongly encouraged to take CHEM 2111, CHEM 2112 and BIOL 4101 as electives. BIEN 4931, BIEN 4710, BIEN 4410, BIEN 4230, BIEN 4600, BIEN 4610, BIEN 4630, BIEN 4420, BIEN 4500, BIEN 4720, BIEN 4510, BIEN 4995 (GPA>3.0), EECE 3110, EECE 3120, EECE 3025 (2 cr.), EECE 3035 (2 cr.), EECE 4620, MEEN 3330, MEEN 3250, MEEN 4240, MEEN 4420, COEN 2710, COEN 4810, COEN 4650, BIOL 4101, BIOL 3702, CHEM 2111, CHEM 2112, MATH 2450, or MATH 4630.

2. Students who place out of MATH 1450 through advanced placement are encouraged to take MATH 1451 and MATH 2450 in place of MATH 1450 and MATH 1455.

3. MEEN Electives — Students may choose two of three Mechanical Engineering courses. MEEN 3220, Dynamics of Mechanical Systems; MEEN 3260, Computer Aided Design; of MEEN 3460, Materials Selection in Mechanical Design. Note: MEEN 3220 is a Prerequisite for MEEN 3260. If not used as a MEEN elective, any of these courses can be used a BIEN elective.

Note: The three Core electives^c specified in this program assume that one of these Core electives is a Dual Application core course. If a Dual Application Core elective is not taken, an additional Core elective is required and the total credit hours increases to 137.

BIOMEDICAL ENGINEERING MINOR

The Department of Biomedical Engineering offers a minor in biomedical engineering to all undergraduate students in the university except those students in biomedical engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met: Twenty-four hours consisting of BIEN 2300, 3300, 4700, 3200, 4320; BIOL 1001; CHEM 2111; (or equivalent). At least half of these credit hours **must** be taken at Marquette University.

OTHER MINORS

Biomedical engineering students can earn minors in a wide variety of areas including computer engineering, electrical engineering, mechanical engineering, biology and chemistry. Interested students should consult with their academic adviser and refer to the appropriate section of the *Undergraduate Bulletin* for specific minor requirements.

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

The Department of Civil and Environmental Engineering offers a curriculum that leads to a bachelor of science degree in civil engineering or a bachelor of science degree in construction engineering and management.

MISSION

The mission of the Department of Civil and Environmental Engineering is to educate students in the Catholic, Jesuit tradition. These students will be competent in their technical fields, appreciate the moral and ethical impact of their professional work, and continue their professional development throughout their careers. The students and faculty of the department will advance the state of technical and scientific knowledge through research and provide service to civic and professional communities.

PROGRAM EDUCATIONAL OBJECTIVES

To carry out the mission of the College of Engineering and the mission of the department described previously, the Department of Civil and Environmental Engineering has established the following Educational Objectives for its undergraduate programs.

- Develop an appreciation for religious, moral, ethical and human values.
- Provide a foundation for the application of the fundamentals of science and mathematics to engineering analysis and design.
- Provide a foundation for understanding the application of civil engineering by giving students an opportunity to experience the civil engineering profession through the co-operative engineering program, service learning, summer internships and/or hands-on experience in laboratory courses.
- Prepare graduates to communicate effectively in written, graphical and oral form.
- Prepare students to be leaders by providing opportunities to exhibit leadership and develop team-building skills.
- Instill a commitment to lifelong learning.

Civil engineering is the art and science used in the construction of facilities which people need in their environment — land, water and air. Airports, buildings, bridges, dams, harbors, highways, irrigation systems, transportation systems, sewerage and water supply systems are examples of the types of facilities which are the responsibility of the civil engineer.

Since the beginning of civilization, people have been building with the use of engineering principles. Modern society depends on this contribution from the civil engineer, whose education is systematically developed from a strong background in mathematics, physical and engineering sciences. The civil engineer must relate to society and fellow men and women, and be aware of how the engineering principles can be applied for the benefit of others.

Civil engineers are also stewards of the land, its resources and environment. Many civil engineers are involved in activities such as watershed and environmental planning, sustainable resource development and environmental protection.

The civil engineering major develops the analysis and design capabilities of the student in the study of structures and systems. The application of computers and pertinent software is used throughout the major. A broad educational program can be selected or some specialization is possible through advised elective course selection.

The curriculum provides the graduate with the necessary training to begin a professional career without further formal education, while also affording those students who enter graduate studies the opportunity to prepare more adequately in their field of specialization.

Civil engineering majors have the option to concentrate their studies in the following areas:

GENERAL CIVIL ENGINEERING

The diverse needs of people and society for many types of constructed facilities give a broad range to civil engineering. This breadth is well-suited to allow specialization in one of the major divisions of this branch of engineering. However, it is not necessary to make a commitment to only one area of concentration while in the undergraduate college. The curriculum at Marquette is arranged to permit students to prepare themselves generally in civil engineering by completing the core courses which provide all the necessary fundamentals and selecting electives to acquire additional depth in one or more of the areas of specialization. All of the electives which the department offers are open to students with the required prerequisites. Selection of the courses for a general program requires careful planning between the student and an academic adviser.

CONSTRUCTION MANAGEMENT

Construction projects of all types require management as well as the traditional engineering skills. This program is arranged so that a student may vary the usual undergraduate program to obtain the knowledge needed to enter a graduate program in construction management while still maintaining the essentials of a general civil engineering program.

Those students who want to focus more on construction engineering and management may be interested in pursuing a bachelor of science degree in construction engineering and management which is also offered by the department.

ENVIRONMENTAL AND WATER RESOURCES

The environmental area is concerned with the control and improvement of human surroundings using principles developed in civil engineering. The environmental/water resources engineer is responsible for conceiving and designing systems for water supply, wastewater treatment and disposal, air pollution control, solid and hazardous waste management and design of water resources systems.

STRUCTURAL

The structural area deals with the planning, analysis, design and construction of various types of structures such as buildings, bridges and foundations. Students will learn to analyze and design structures in steel and concrete. They will also learn to analyze and design foundations for structures.

TRANSPORTATION

The transportation area provides the student with an overall understanding of the problems of transportation and urban planning, and how to solve them. Students may elect to concentrate in the area of highway engineering (design, pavements and materials) or traffic engineering (design, operations and traffic management).

CIVIL ENGINEERING MAJOR

Freshman

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
MATH 1450 ^b	4	MATH 1451 ^b	4
CHEM 1001 ^b	4	CHEM 1002 ^b	4
Core Rhetoric 1 ^f	3	Core Rhetoric 2 ^f	3
Core elective ^c (HCS)	3	Core elective ^c (ISB)	3
GEEN 1200	3	GEEN 1210	3
	17		17

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
MATH 2450	4	MATH 2451	4
PHYS 1003 ^b	4	CEEN 2120	3
GEEN 2952	0	CEEN 3320	3
CEEN 2110	3	MEEN 2402	2
CEEN 2310	3	Core elective ^c /Free elective ^d (LPA)	3
Core elective ^c (DC)	3		
	17		15

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CEEN 2130	3	CEEN 3210	3
CEEN 3150	3	CEEN 3140	3
CEEN 3160	3	CEEN 3610	3
CEEN 3510	3	CEEN 3810	3
Cross-disciplinary Engineering elective ¹	3	Science elective ²	3
PHIL 1001 ^b	3		
	18		15

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CEEN 3430	3	CEEN 4997	4
CEEN 3440	3	CEEN Technical elective	3
CEEN 4710	1	CEEN Technical elective (Design)	3
THEO 1001 ^b	3	PHIL 2310 ^b	3
CEEN Technical elective	3	Theology elective ^c	3
CEEN Technical elective (Design)	3		
	16		16

Total Credit Hours: 131

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1 Either ELEN 3001 or MEEN 3310. 2 A science elective in addition to the CHEM and PHYS course is required. Courses in areas such as biology, geology and meteorology may be selected subject to approval by the advisor, department chair and associate dean.

TECHNICAL ELECTIVE REQUIREMENTS

All civil engineering majors must complete 12 credits of technical electives from the courses listed below. A minimum of 6 credits of civil engineering design is required and must be selected from those courses designated as design (D).

CEEN 3220 (D)	CEEN 4340 (D)	CEEN 4540
CEEN 3615 (D)	CEEN 4350	CEEN 4545
CEEN 3620 (D)	CEEN 4411	CEEN 4650 (D)
CEEN 3625 (D)	CEEN 4431 (D)	CEEN 4660
CEEN 3630 (D)	CEEN 4441 (D)	CEEN 4670
CEEN 3640 (D)	CEEN 4442 (D)	CEEN 4715 (D)
CEEN 3645 (D)	CEEN 4450 (D)	CEMA 3850 (D)
CEEN 4145	CEEN 4460 (D)	CEMA 4815
CEEN 4230 (D)	CEEN 4515	CEMA 4820
CEEN 4240 (D)	CEEN 4520	CEMA 4825
CEEN 4250	CEEN 4525 (D)	CEMA 4830
CEEN 4310	CEEN 4530	CEMA 4840
CEEN 4320	CEEN 4535	CEMA 4850

(D) designates a Civil Engineering design course.

Exceptions to requirements: Students enrolled in NROTC or AROTC may substitute approved naval science or military science courses.

The civil engineering major provides for elective courses which enable a student to study in depth or breadth those areas which best meet individual interests and needs. In this way, any student, after consultation with an adviser and approval by the department chairperson, can follow a special program which fulfills the technical elective credit requirement. The electives listed in the following table are those which would normally be used for this purpose. These are meant to be only suggestions and it is the responsibility of the student and an adviser to develop a well planned elective program.

TABLE OF TECHNICAL ELECTIVE COURSES

COURSES			Design	Environmental Option	Structural Option	Transportation Option	Construction Management Option
CEEN	3220	River Engineering			HR		R
CEEN	3615	Highway Planning and Design	X		HR		
CEEN	3620	Highway Interchange Design	X	HR			
CEEN	3625	Urban Street Design	X	HR		R	R
CEEN	3630	Airport Planning and Design		R		R	
CEEN	3640	Traffic Characteristics and Design	X	R		R	
CEEN	3645	Traffic Engineering		R			
CEEN	4145	Advanced Mechanics of Materials		R		R	
CEEN	4230	Urban Hydrology and Storm Water Management			R		
CEEN	4240	Water Resources Engineering	X		HR		R
CEEN	4250	Groundwater Engineering	X		HR		R
CEEN	4310	Geographical Information Systems	X		HR	R	
CEEN	4320	Engineering Decisions Under Uncertainty	X	R	R	R	R
CEEN	4340	Urban Planning For Civil Engineers		HR			
CEEN	4350	Law for Engineers	X	R			
CEEN	4411	Matrix Analysis	X	HR			
CEEN	4431	Steel Design 2		R			
CEEN	4441	Advanced Concrete and Masonry Design		R			
CEEN	4442	Prestressed Concrete Design		R			
CEEN	4450	Bridge Design	X		R		HR
CEEN	4460	Foundation Engineering	X			HR	
CEEN	4515	Environmental Chemistry	X			HR	
CEEN	4520	Industrial Wastewater Management	X			HR	
CEEN	4525	Treatment Plant Design and Operation	X			R	
CEEN	4530	Hazardous and Industrial Waste Management				HR	R
CEEN	4535	Environmental Engineering Microbiology	X			HR	
CEEN	4540	Municipal Solid Waste Management				HR	R
CEEN	4545	Air Pollution Engineering	X			HR	
CEEN	4650	Pavement Design				HR	
CEEN	4660	Pavement Management			R		HR
CEEN	4670	Advanced Transportation Materials	X	R		HR	R
CEEN	4715	Sustainable Engineering		R	R	R	R
CEMA	3850	Construction Equipment and Methods	X				HR
CEMA	4815	Mechanical and Electrical Systems					HR
CEMA	4820	Construction Operations and Improvement					HR
CEMA	4825	E-Business in the Construction Business					HR
CEMA	4830	Construction Planning, Scheduling and Control					HR
CEMA	4840	Construction Cost Analysis and Estimating		R	R	R	HR

R = Recommended; HR = Highly Recommended

ENVIRONMENTAL ENGINEERING MAJOR

In addition to the Civil Engineering major described above, students may elect to specialize in environmental engineering and obtain a major in that discipline. The major in Environmental Engineering provides a solid foundation in civil engineering as well as more comprehensive study in the area related to the environment.

Freshman and Sophomore

The freshman year is the same as that described for the civil engineering major.

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
MATH 2450	4	MATH 2451	4
PHYS 1003 ^b	4	CEEN 2120	3
GEEN 2952	0	CEEN 3320	3
CEEN 2110	3	MEEN 2402	2
CEEN 2310	3	Core elective ^c /Free elective ^d (LPA)	3
Core elective ^c (DC)	3		
	17		15

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CEEN 2130	3	CEEN 3210	3
CEEN 3150	3	CEEN 3410	3
CEEN 3160	3	CEEN 3610	3
CEEN 3510	3	CEEN 3810	3
CEEN 4515	3	Science elective ⁴	3
MEEN 3310	3		
	18		15

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
Environmental technical elective	3	CEEN 4997	4
CEEN 4710	1	Environmental technical elective	3
CEEN 4953 ¹	0	Environmental technical elective (Design)	3
Structural Design elective ³	3	PHIL 2310 ^b	3
Environmental technical elective (Design)	3	Theology elective ^c	3
PHIL 1001b	3		
THEO 1001 ^b	3		
	16		16

Total Credit Hours: 131

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1 Participation in CEEN 4953, Environmental Seminar, is required during either the first or second term of the senior year.

2 Either BIOL 1001, BIOL 2401 or CEEN 4535

3 Either CEEN 3430 or CEEN 3440

4 A science elective in addition to the CHEM and PHYS course is required. Courses in areas such as biology, geology and meteorology may be selected subject to approval by the advisor, department chair and associate dean.

ENVIRONMENTAL ELECTIVES

Nine credits are required from the following list. Six credits must be selected from those designated as design (D).

CEEN 3220 (D)	CEEN 4310	CEEN 4530	CEEN 4715 (D)
CEEN 4230 (D)	CEEN 4340 (D)	CEEN 4535	
CEEN 4240 (D)	CEEN 4520 (D)	CEEN 4540	
CEEN 4250	CEEN 4525 (D)	CEEN 4555	

CONSTRUCTION ENGINEERING AND MANAGEMENT MAJOR

In addition to the Civil Engineering and Environmental majors described above, students may elect to specialize in construction engineering and obtain a bachelor of science degree in that discipline.

Freshman

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CHEM 1001 ^b	4	CHEM 1002 ^b	4
Core Rhetoric 1 ^f	3	Core Rhetoric 2 ^f	3
GEEN 1200	3	GEEN 1210	3
MATH 1450 ^b	4	MATH 1451 ^b	4
Core elective ^{c,1}	3	ECON 1001 ^{b,1}	3
	17		17

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
PHYS 1003 ^b	4	CEEN 3320	3
MATH 2450	4	MATH 2451	4
GEEN 2951	0	ACCO 2031	3
CEEN 2110	3	Core elective ^{c,1}	3
CEEN 2310	3	CEMA 3810	3
ACCO 2030	3		
	17		16

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CEEN 2130	3	MEEN 2402	2
CEEN 3160	3	CEEN 3410	3
CEMA 3860	3	CEEN 4350	3
MATH 4720	3	CEMA 4815	3
HURE 3001	3	FINA 3001	3
PHIL 1001 ^b	3	CMST 1300	2
	18		16

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CEMA 3850	3	CEEN 4997	4
CEMA 4830	3	CEMA 4840	3
PHIL 2310 ^b	3	CORE elective ^{c,1}	3
CEEN technical elective ²	3	CEEN technical elective (design) ²	3
THEO 1001 ^b	3	THEO elective ^e	3
	15		16

Total Credit Hours: 132

1 As ECON 1001 which meets the Core Individual and Social Behavior knowledge area, remaining Core electives should be taken so as to address History of Cultures and Societies, Literature and Performing Arts, and Diverse Cultures.

2 Note that co-op is required for the CEMA program. One academic credit is awarded for each co-op work term completed, three of which can be used as a technical elective towards degree requirements.

TECHNICAL ELECTIVES:

CEEN 3430 (D)	CEEN 3610	CEEN 4650 (D)
CEEN 3440 (D)	CEEN 4230 (D)	CEEN 4715 (D)
CEEN 3510	CEEN 4460 (D)	

CIVIL ENGINEERING MINOR

The Department of Civil and Environmental Engineering offers a minor in civil engineering to all undergraduate students in the university except those students in civil or environmental engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met: Twenty-five hours including required courses CEEN 2122, (or CEEN 2110 and 2120), 2130, 3150 and at least 12 additional hours, from the following CEEN courses: CEEN 2310, 3160, 3410, 3510, 3610, or CEMA 3810, with additional needed credits from any upper-division CEEN course. The program as a whole must have departmental approval and be completed with a C average. At least half of these credit hours **must** be taken at Marquette University.

ENVIRONMENTAL ENGINEERING MINOR

The Department of Civil and Environmental Engineering offers a minor in environmental engineering to all undergraduate students in the university except those students in civil or environmental engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met: Twenty-two hours including required courses CEEN 2122, (or CEEN 2110 and 2120), 3150, BIOL 1001 or CHEM 2111, CEEN 3510 and at least nine additional hours from the following courses: CEEN 3210, 3220, 4230, 4240, 4250, 4515, 4520, 4525, 4530, 4535 and 4540. The program as a whole must have departmental approval and be completed with a C average. At least half of these credit hours **must** be taken at Marquette University.

OTHER MINORS

Students in the civil engineering curriculum who are interested in obtaining a minor (or major) in any other area should consult with their advisers during their freshman or sophomore year in order to plan their schedules to meet their particular objectives with a minimum amount of overload credits.

FIVE-YEAR B.S./M.S. PROGRAM

The department offers a five-year combined B.S./M.S. program available to outstanding undergraduate students. This program enables students to earn both their bachelor of science and master of science degrees in civil engineering in just five years. Students currently enrolled in the undergraduate program in civil and environmental engineering at Marquette University (with a GPA of 3.500 or above) may apply for admission to the five-year program during their junior year. Students must submit an application to the Graduate School, indicate their interest in the five-year program, and meet all other admission criteria as stated in the Application Requirements section of the *Graduate Bulletin*.

In addition to completing their undergraduate degree requirements, students will take master's level courses during their senior year. (*Note that no course is permitted to satisfy both the undergraduate and graduate degree requirements in the Five-year B.S./M.S. Program of the Department of Civil and Environmental Engineering.*) The remaining master's level course work is taken during the student's fifth year. Students are strongly encouraged to pursue Plan A (thesis option), in which case work on the thesis research should begin during the summer between the junior and senior years. Students will continue to gain research experience during the summer between senior and fifth years, continuing throughout the fifth year and culminating in preparation of a written thesis and defense. Combined B.S./M.S. programs following Plan B (course work option) may also be designed for completion in five years. See the *Graduate Bulletin* for further details.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

The Department of Electrical and Computer Engineering offers curricula that lead to a bachelor of science degree in electrical engineering or a bachelor of science degree in computer engineering.

MISSION

The Department of Electrical and Computer Engineering embraces the missions of Marquette University and its College of Engineering. The mission of the Department of Electrical and Computer Engineering is to offer its students high-quality, up-to-date, nationally-recognized programs in electrical and computer engineering that prepare them for successful careers. This success is marked by a commitment to lifelong learning and a deep concern for the impact of their work on others; by research that advances the frontiers of technical and scientific knowledge; and by service to professional and civic communities.

Engineering is the professional art of applying science and mathematics to the efficient conversion of natural resources and to the manipulation of information for human benefit. The basic concepts in this definition can be expanded, particularly for the electrical or computer engineer, by considering his or her activities. These usually involve 1) the processing and control of energy, 2) the processing and control of information, 3) the processing and control of materials. Certainly any educational experience in electrical engineering or computer engineering should be evaluated for the student in terms of its contribution in one or more of these areas.

However, this is not the only consideration. Equally important is the concept of engineering as a *dynamic* profession. In terms of the educational process, this means that attention must be directed to preparing the student for types of processing and control which have not yet been

developed or perhaps even discovered. The young engineer must be prepared to cope with devices and systems which will appear years into the future, from the viewpoint of the scientific principles on which the design of these future devices and systems will be based.

There is another important consideration in the practice of electrical and computer engineering. An engineer is called on for many and varied activities but as diversified as these may be, when carefully examined, they lead to this conclusion: *Problem-solving is the engineer's most important activity*. From the educator's viewpoint, this naturally should lead to a planned, conscious effort to develop the young engineer's problem-solving ability to the limits of his or her God-given talents. In this regard, it is important to note that since engineers' problems are sometimes *creative*, sometimes *analytic*, and sometimes *experimental*, their educational experience must give practice in each of these areas and in all types of problems. Significant design experience is an essential part of the engineer's education.

Finally, the engineer is an *individual*, a citizen who needs to develop a sense of moral and ethical values on a plane consistent with his or her education in other areas. In the educational process, this requires that a good balance be developed between the technical and social-humanistic content.

The electrical engineering and computer engineering curricula at Marquette University are carefully designed to meet the requirements of each student. Opportunities are provided for each student to develop in the direction of personal interests and at a rate corresponding to individual ability. Coherent elective programs are planned with each student consistent with his or her ability and professional goals. Moreover, superior students have the opportunity for independent study and for participation in research activity.

ELECTRICAL AND COMPUTER ENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

The Educational Objectives for the Electrical Engineering and Computer Engineering Programs derive from the Department's vision for our graduates. Alumni of these programs, particularly those individuals who have completed their undergraduate education within the last two to five years, will be thriving professionals who apply the knowledge, skills, and values gained through their study of Computer or Electrical Engineering at Marquette University.

Specifically, our graduates are:

1. Engaged in solving significant problems in engineering or another field, as employees in the public or private sector, or as students pursuing an advanced or professional degree, or as volunteers.
2. Capably contributing as members of engineering or other problem-solving teams and communicating effectively both within the team and to the team's clients.
3. Advancing in their professional careers — taking on increasing responsibilities as well as leadership roles.
4. Continually learning, whether in a formal degree program or by participating in professional conferences and continuing education programs.
5. Acting responsibly when making professional and personal decisions — serving as examples to those around them.

Electrical Engineering

Two curricula offered in the Department of Electrical and Computer Engineering lead to the bachelor of science degree in electrical engineering.

ELECTRICAL AND ELECTRONIC ENGINEERING MAJOR

The *electrical and electronic engineering major* provides students with a comprehensive electrical engineering background including course specialties in three broad categories: *materials and devices*, *devices and circuits*, and *circuits and systems*. *Materials and devices* involves the development of methods for characterizing materials and devices constructed from these materials, the development of new manufacturing and processing technologies, and the design and fabrication of electronic components. *Devices and circuits* work ranges from the design of electronic components to the development of complete circuits employing these devices. *Circuits and systems* involves the application of devices and circuits to full-scale consumer and industrial products which employ various solid state devices and transducers, electromechanical and otherwise.

Electrical and Electronic Engineering Major

Freshman

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CHEM 1001 ^b	4	EECE 1610	3
ENGL 1001 ^f	3	ELEN 1954	1
GEEN 1200	3	Core Rhetoric 2 ^f	3
MATH 1450 ^b	4	GEEN 1210	3
Core elective ^c	3	MATH 1451 ^b	4
ELEN 1953	1	Core elective ^c	3
	18		17

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2010 ¹	3	EECE 2035	1
EECE 2015 ¹	1	EECE 3010 ¹	3
EECE 2710 ¹	3	ELEN 2020 ¹	3
GEEN 2952	0	MATH 2451	4
MATH 2450	4	PHYS 1004 ^b	4
PHIL 1001 ^b	3	THEO 1001 ^b	3
PHYS 1003 ^b	4		
	18		18

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2030 ¹	4	CEEN 2122	4
ELEN 3020	4	EECE 3015	2
ELEN 3025 ¹	2	ELEN 3030 ¹	4
ELEN 3110 ¹	4	ELEN 3120	3
PHIL 2310 ^b	3	ELEN 3210	2
	17		16

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
ELEN 3035	2	ELEN 4998	3
ELEN 4430	3	EECE Technical elective ³	3
ELEN 4920	3	Science/Math elective	3
MATH 4720	3	Core elective ^c	3
Design elective ⁴	3	Core elective ^c /Free elective ^d	3
THEO elective ^e	3		
	17		15

Total Credit Hours: 136

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1 A C or better grade is required in these courses to meet the prerequisites for subsequent computer and/or electrical engineering required courses.

2 These electives will normally be an upper division elective in EECE, COEN, COSC, MATH, PHYS and/or CHEM. Other courses may be acceptable with prior approval of the department.

3 The science/math elective can be fulfilled with any upper division math or physics course or any biology or chemistry course for which the prerequisite requirements are met.

4 This elective must be chosen from ELEN (4130, 4210, 4220, 4230, 4240, 4250, 4310, 4320, 4450, 4460, 4565, 4570); EECE (4410, 4510); COEN (4650, 4710, 4830); and [ELEN (4015, 4995) and COEN (4690, 4790 and 4995) with department approval as a design elective].

Electrical and Computer Engineering Major

The electrical and computer engineering major provides students with a comprehensive electrical engineering background that contains a greater exposure to and more in-depth study of computer principles and applications. The *electrical and computer engineering major* offers a carefully integrated course of instruction in electrical engineering, computer engineering and mathematics, to provide a student with a broader computer background than does the *electrical and electronic engineering major*. The *electrical and computer engineering major* includes a course in data structures and an integrated two-term sequence in computer software and hardware. The emphasis in these courses is on small computers, particularly microcomputer concepts and

applications. Students completing the electrical and computer engineering major may satisfy the requirements for a minor in computer science (COSC) from the Klingler College of Arts and Sciences by an appropriate selection of their program elective, technical elective, and science/math elective, and one overload course. If the core electives are chosen to satisfy footnote d, the resulting free elective will eliminate the need for an overload course.

Electrical and Computer Engineering Major

Freshman

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CHEM 1001 ^b	4	EECE 1610	3
ENGL 1001 ^f	3	ELEN 1954	1
GEEN 1200	3	Core Rhetoric 2 ^f	3
MATH 1450 ^b	4	GEEN 1210	3
Core elective ^c	3	MATH 1451 ^b	4
ELEN 1953	1	Core elective ^e	3
	18		17

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2010 ¹	3	EECE 2035	1
EECE 2015 ¹	1	EECE 3010 ¹	3
EECE 2710 ¹	3	ELEN 2020 ¹	3
GEEN 2952	0	MATH 2451	4
MATH 2450	4	PHYS 1004 ^b	4
PHIL 1001 ^b	3	THEO 1001 ^b	3
PHYS 1003 ^b	4		
	18		18

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2030 ¹	4	CEEN 2122 ²	4
ELEN 3020	4	COEN 4710	3
ELEN 3025 ¹	2	COSC 2010	3
ELEN 3110 ¹	4	EECE 3015	2
PHIL 2310 ^b	3	ELEN 3030 ¹	4
	17		16

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
ELEN 3035	2	ELEN 4998	3
ELEN 4920	3	EECE program elective ³	3
MATH 4720	3	EECE technical elective ⁴	3
Design elective ⁵	3	Core elective ^c	3
Science/Math elective ⁶	3	Core elective ^e /Free elective ^d	3
THEO elective ^e	3		
	17		15

Total Credit Hours: 136

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1 A C or better grade is required in these courses to meet the prerequisites for subsequent computer and/or electrical engineering required courses.

2 Students may also choose CHEM 1002 in place of CEEN 2122.

3. Program electives must be chosen from the following list: any design elective for the electrical and computer engineering major (footnote 5 below); COEN (4610, 4820); COSC (3410, 3550, 4110, 4400) and [ELEN (4015, 4995) and COEN (4690, 4790 and 4995) with departmental approval as a program elective].

4. These electives will normally be upper division electives in EECE, COEN, COSC, MATH, PHYS and/or CHEM. Other courses may be acceptable with prior approval of the department.

5. This elective must be chosen from the following courses with a computer design emphasis: ELEN (4310, 4320, 4450, 4460, 4570); EECE (4410, 4510); COEN(4620, 4630, 4650, 4720, 4730, 4810, 4830, 4840, 4850, 4860, 4870); and [ELEN (4015, 4995) and COEN (4690, 4790 and 4995) with departmental approval as a design elective].

6. The science/math elective can be fulfilled with any upper division math or physics course or any biology or chemistry course for which the prerequisite requirements are met. If CHEM 1002 is selected instead of CEEN 2122 as described in footnote 2, this elective becomes an EECE/Technical elective (see footnote 4).

AREAS OF CONCENTRATION WITHIN ELECTRICAL ENGINEERING

ELECTRICAL AND ELECTRONIC MAJOR: various areas of concentration are available with the appropriate choice of the design elective and the EECE/technical elective. While there is no requirement to concentrate in one area, it is essential that the student select an appropriate and well-planned elective program. The various areas of concentration are described below.

CONTROL SYSTEMS

Control system engineering develops a general background in automatic controls and systems engineering with a fundamental emphasis on linear feedback systems and applications of computers. Course work in advanced controls, digital systems, and large-scale design is included. Recommended courses in the control systems area of concentration include: EECE 4310†, EECE 4320†, ELEN 4450†, EECE 4510†, EECE 4560†.

ELECTRONICS

The electronics area offers courses in microelectronics, high frequency and optical electronics, solid state materials and devices, and electronic circuit analysis and design.

A. Solid State Electronics and Materials

Solid state electronics courses include solid state physics and the construction, measurement and utilization of solid state electronic devices such as p-n junctions, MOSFETs, Gunn diodes, silicon controlled rectifiers and the diverse area of integrated circuits. Solid state materials courses study the electrical, physical and mechanical properties of materials as they relate to the present and future requirements of the electrical manufacturing industry.

Recommended courses in the solid state electronics and materials area of concentration include: EECE 4410†, ELEN 4450†

B. Applied Electromagnetics and Waves

Applied electromagnetics and waves involve high frequency waves as applied to communications and sensing applications. Principles and applications of wireless communications are included. Fiber optics, antennas, modern communication cell systems, analog and digital modulation techniques, and sensor principles and applications are investigated.

Recommended courses in the applied electromagnetics and waves area of concentration include: ELEN 4130†, ELEN 4450†, ELEN 4460†, ELEN 4560, ELEN 4565†, ELEN 4570†.

C. Electronic Circuit Analysis and Design

Electronic circuit analysis and design involve utilization of feedback and switching theory along with linear and digital, discrete and integrated circuits to construct modern electronic circuits.

Recommended courses in the electronic circuit analysis and design area of concentration include: ELEN 4220†, ELEN 4460†, COEN 4710†, COEN 4720†.

POWER

Power engineering emphasizes the control and conversion of electrical energy. Motors and generators with their associated electronic power controls, power distribution systems and control systems are examined. Modern computer-aided analysis is brought to bear on the design and analysis of power devices and power systems.

Recommended courses in the power concentration area include: ELEN 4150†, ELEN 4210, ELEN 4220†, ELEN 4230†, ELEN 4240†, ELEN 4250†.

†Design Elective

ELECTRICAL AND COMPUTER MAJOR: software and hardware areas of concentration are available through the appropriate choice of the design elective, the program elective, and the EECE/technical elective.

COMPUTER SOFTWARE

Recommended courses in the computer software area of concentration include: COEN 4620, COEN 4630†, COEN 4650†, COEN 4690†, COEN 4810†, COEN 4820†, COEN 4830†, COEN 4840†, COEN 4850†, COEN 4860†, COEN 4870†.

COMPUTER HARDWARE

Recommended courses in the computer hardware area of concentration include: COEN 4720†, COEN 4730†, EECE 4410†, EECE 4510†.

†Design Elective

CHOOSING ELECTIVES

In choosing electives, the faculty adviser and student confer to determine what the student's individual interests and objectives are and then what upper division elective courses best meet his or her needs. By careful choice of an elective program the student can obtain in-depth knowledge in one area of concentration in addition to the broad fundamental background developed in the required courses. Or by equally careful choice of an elective program, the student may continue development of a broad fundamental background. It is the responsibility of the student and his or her faculty adviser to select an appropriate, well-planned elective program. It is possible for students completing the requirements for the bachelor's degree in electrical engineering to also earn a minor in mathematics by carefully choosing their elective program. For those students completing the requirements for the electrical and computer engineering major, alternatively, a minor in computer science may be possible.

COMPUTER SCIENCE MINOR

Students in engineering may obtain a minor in computer science by completing the following course requirements with a grade of C or better in each: (EECE 1610, EECE 2710, COSC 2010 and MATH 2105, plus three additional courses (nine credits) from the following list: (COSC 3100, 3300, 3410, 3550, 4110, 4400, 4610, 4860). Overload hours can be minimized in consultation with an academic adviser.

OTHER MINORS

Students in the electrical engineering curriculum who are interested in obtaining a minor (or major) in any other area should consult with their advisers during their freshman or sophomore year in order to plan their schedules to meet their particular objectives with a minimum amount of overload credits.

ELECTRICAL ENGINEERING MINOR

The Department of Electrical Engineering offers a minor in electrical engineering to undergraduate students in the university except those students in electrical engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met:

A minimum of twenty-eight hours including: EECE 2010, EECE 2015, ELEN 2020, EECE 2030, EECE 2035, EECE 3010, ELEN 3020, ELEN 3025, ELEN 3030, and either (EECE 2710 or ELEN 3110) or (ELEN 3015 or ELEN 3035). At least half of these credit hours must be taken at Marquette University and a C or better average must be earned in the relevant courses taken at Marquette University.

FIVE YEAR B.S./M.S. PROGRAM

This program allows students to receive a bachelor of science degree in either electrical engineering or computer engineering, depending on the student's undergraduate major, and a master of science degree in electrical engineering in five years. Students with qualifying grade point averages enroll in the program during their junior year. Additional information about this program is available in the most recent Marquette University Graduate Bulletin.

Computer Engineering

In addition to the two electrical engineering majors outlined above, the Department of Electrical and Computer Engineering offers a curriculum leading to a bachelor of science degree in computer engineering. The computer engineering curriculum provides a solid foundation in electrical engineering fundamentals, as well as a comprehensive study of computer software and hardware systems. Through an ample elective program, students can customize their studies to their individual interests, emphasizing hardware engineering, software engineering, intelligent systems, or applications.

Computer Engineering

Freshman

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CHEM 1001 ^b	4	EECE 1610	3
ENGL 1001 ^f	3	ELEN 1954	1
GEEN 1200	3	GEEN 1210	3
MATH 1450 ^b	4	MATH 1451 ^b	4
Core elective ^c	3	Core elective ^c	3
ELEN 1953	1	Core Rhetoric 2 ^f	3
	18		17

Sophomore

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
COSC 2010	3	COEN 2020	3
EECE 2010 ¹	3	COEN 2610	3
EECE 2015 ¹	1	EECE 2035	1
EECE 2710 ¹	3	EECE 3010	3
GEEN 2952	0	MATH 2451	4
MATH 2450	4	THEO 1001 ^b	3
PHIL 1001 ^b	3		
	17		17

Junior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
EECE 2030 ¹	4	COEN 4710	3
MATH 4720	3	COEN 4820	3
PHIL 2310 ^b	3	EECE 3015	2
PHYS 1003 ^b	4	MATH 2105	3
Core elective ^c	3	PHYS 1004 ^b	4
	17	COEN technical elective ²	3
			18

Senior

FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
COEN 4720	3	COEN 4998	3
COEN 4920	3	COEN technical elective ²	3
COEN technical elective ²	3	COEN technical elective ²	3
COEN technical elective ²	3	COEN technical elective ²	3
COEN technical elective ²	3	Core elective ^e /Free elective ^d	3
THEO elective ^e	3		
	18		15

Total Credit Hours: 137

a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

1. A C or better grade is required in these courses to meet the prerequisites for subsequent computer and/or electrical engineering required courses.
2. At least five of the seven electives must be COEN design electives. The remaining two electives can be in any technical area.
3. Of the five COEN design electives, one must be in the Hardware area, one must be in the Software area, and one must be in either the Intelligent Systems area or the Applications area. Of the five COEN design electives, three must be in one of the following areas: Hardware, Software, Intelligent Systems, and Applications. A course listed in two concentration areas may be counted toward only one elective requirement.

AREAS OF CONCENTRATION WITHIN COMPUTER ENGINEERING

The Computer Engineering curriculum has seven electives designated as COEN/TECH electives. At least five of these electives must be courses with a COEN number. The remaining two electives can be in any technical area. The student, in consultation with his or her advisor, must design the elective program to meet both a breadth requirement and a depth requirement. To meet the breadth requirement, one COEN elective must be in the Hardware area, a second COEN elective must be in the Software area, and a third COEN elective must be in either the Intelligent Systems area or the Applications area. To meet the depth requirement, a total of three COEN electives must be in one of the following four areas: Hardware, Software, Intelligent Systems, and Applications. These areas of concentration and the courses in each area are described below.

Hardware

Hardware includes the study of computer architectures, computer chip technology, peripheral devices, signal processing, interface design, and the like. The following COEN elective courses are available in the Hardware area:

- COEN 4730 Computer Architecture
- COEN 4790 Developments in Computer Hardware
- EECE 4410 Integrated Microelectronic Circuits
- EECE 4510 Digital Signal Processing

Software

Software emphasizes the design of software systems and includes concerns such as the user interface, expansibility and maintainability, efficiency in time and computing resources, software testing, security, etc. The following COEN elective courses are available in the Software area:

- COEN 4610 Object-Oriented Software Engineering
- COEN 4620 Modern Programming Practices
- COEN 4630 Software Testing
- COEN 4690 Developments in Computer Software
- COEN 4840 Computer Security

Intelligent Systems

Intelligent Systems includes the study of artificial intelligence, neural networks, evolutionary computing, design of algorithms, and computer security models. Students wishing to concentrate in this area are encouraged to take ELEN 3020 as one of their non-COEN electives. The following COEN elective courses are available in the Intelligent Systems area:

- COEN 4650 Introduction to Algorithms
- COEN 4840 Computer Security
- COEN 4850 Introduction to Intelligent Systems
- COEN 4860 Introduction to Neural Networks and Fuzzy Systems
- COEN 4870 Evolutionary Computing
- EECE 4510 Digital Signal Processing

Applications

The Applications area includes the study of database systems, computer graphics, software testing, and computer security. The following COEN elective courses are available in the Applications area:

- COEN 4620 Modern Programming Practices
- COEN 4630 Software Testing
- COEN 4640 Computer Security
- COEN 4690 Development in Computer Software
- COEN 4810 Database Applications
- COEN 4830 Introduction to Computer Graphics

Graduate Study

The COEN curriculum provides an excellent foundation for students wishing to pursue graduate studies in most computer engineering, computer science, and electrical engineering graduate programs. However, students who wish to enter the Marquette University graduate program in Electrical Engineering must take ELEN 3020 as one of their two non-COEN electives in order to meet the entrance requirements.

COMPUTER SCIENCE MINOR

Students in engineering may obtain a minor in computer science by completing the following course requirements with a grade of C or better in each of: EECE 1610, EECE 2710, COSC 2010 and MATH 2105, plus three additional courses (nine credits) from the following list: COSC 3100, 3300, 3410, 3550, 4110, 4400, 4610, and 4860. Overload hours can be eliminated or minimized in consultation with an academic adviser.

OTHER MINORS

Students in the electrical engineering curriculum who are interested in obtaining a minor (or major) in any other area should consult with their advisers during their freshman or sophomore year in order to plan their schedules to meet their particular objectives with a minimum amount of overload credits.

COMPUTER ENGINEERING MINOR

The Department of Electrical and Computer Engineering offers a minor in computer engineering to undergraduate students in the university except those students in computer engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met: A minimum of thirty hours including: EECE 2010, EECE 2015, COEN 2020, EECE 2030, EECE 2035, COEN 2610, EECE 2710, EECE 3010, COEN 4710, COEN 4720, and COEN 4820. At least half of these credit hours must be taken at Marquette University and a C or better average must be earned in the relevant courses taken at Marquette University.

FIVE YEAR B.S./M.S. PROGRAM

This program allows students to receive a bachelor of science degree in either electrical engineering or computer engineering, depending on the student's undergraduate major, and a master of science degree in electrical engineering in five years. Students with qualifying grade point averages enroll in the program during their junior year. Additional information about this program is available in the most recent Marquette University Graduate Bulletin.

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers curricula that lead to a bachelor of science in mechanical engineering.

MISSION

In embracing the missions of the university and the College of Engineering, it is the mission of the Department of Mechanical Engineering to offer a high quality, up-to-date, nationally-recognized engineering program which prepares students for successful careers. This success is marked by the graduates' commitment to lifelong learning; a deep concern for the impact of their work on others; research that advances technical and scientific knowledge; and service to professional and civic communities. The department also strives to develop students and faculty who will be recognized as exceptional in their pursuit of excellence, sense of community, spirit of collaboration, and ability to define problems and accomplish goals.

Mechanical Engineering Major

Mechanical engineering is that branch of engineering which is concerned with mechanical and energy systems, along with the intelligent use of modern materials. Mechanical engineers conceive, plan, design, and direct the manufacture, distribution, and operation of a wide variety of devices, machines, and systems for energy conversion, environmental control, materials processing, transportation, materials handling, and other purposes. The field of mechanical engineering is very broad, and the profession thus provides an ideal base for interdisciplinary activities.

Engineers are constantly challenged to advance and implement modern technologies. This challenge can be met provided that one obtains a sound knowledge of the fundamental principles of the engineering sciences. The mechanical engineering curriculum is designed to provide not only a thorough understanding of the engineering sciences but also of the principles of manufacturing and organization that are used to implement these fundamentals in practical engineering applications.

Integrated with the technical and scientific content of the program is a series of required and elective courses in the humanities, social sciences, theology, philosophy, and communication arts. These courses provide the student with an understanding of society and an awareness of his or her social responsibilities.

In order to accommodate the students' professional interests, the department offers electives in a number of areas of study within mechanical engineering. In choosing electives, the student and faculty adviser confer to determine those courses which best meet the needs and interests of the individual student. By carefully selecting technical elective coursework, the student can obtain in-depth knowledge in one or possibly two areas of study to compliment the broad, fundamental, required courses.

The mechanical engineering curriculum is outlined below and then followed by a description of the areas of study and the corresponding technical elective courses for each.

EDUCATIONAL OBJECTIVES

Mechanical Engineering graduates are prepared to:

1. Solve mechanical engineering problems in the areas of mechanical systems, thermal/fluid systems, and manufacturing systems by applying fundamental knowledge in mathematics and science.
2. Solve open-ended (design-oriented) problems by judiciously applying the skills of perception, synthesis, analysis, selection/rationale, realization, verification, collaboration, and communication.
3. Collaborate effectively within a professional environment by consistently demonstrating the personal characteristics of productivity, responsibility, integrity, supportiveness, and enthusiasm.
4. Take ownership of their own personal and career advancement.

MECHANICAL ENGINEERING MAJOR

<i>Freshman</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
ENGL 1001 ^b	3	Core Rhetoric 1002 ^f	3
GEEN 1200	3	GEEN 1210	3
MATH 1450 ^b	4	MATH 1451 ^b	4
PHYS 1003 ^b	4	PHYS 1004 ^b	4
Core elective ^c	3	Core elective ^c	3
	17		17
<i>Sophomore</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
CHEM 1001 ^b	4	CHEM 1002 ^b	4
MEEN 2110	3	MEEN 2120	3
GEEN 2952	0	MEEN 2130	3
MEEN 2460	3	MEEN 2210	3
MATH 2450	4	MATH 2451	4
Core elective ^c	3		
	17		17
<i>Junior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
MEEN 3220	3	MEEN 3210	4
MEEN 3310	3	MEEN 3250	3
MEEN 3320	3	MEEN 3330	3
MEEN 3426	3	MEEN 3443	3
MEEN 3460	3	PHIL 2310 ^b	3
PHIL 1001 ^b	3		
	18		16
<i>Senior</i>			
FIRST TERM	^a SEM. HRS.	SECOND TERM	^a SEM. HRS.
MEEN 3260	3	MEEN 4998	3
MEEN 3340	3	MEEN elective	3
MEEN 4920	3	MEEN elective	3
MEEN 4590 ¹	1	Theology elective	3
MEEN elective	3	Core elective ^c /Free elective ^d	3
THEO 1001 ^b	3		
	16		15
Total Credit Hours:			133

^a For footnotes b, c, d, e, f refer to the College of Engineering section of this bulletin for details related to these footnotes.

¹ As part of the requirements for this course, students must take the State of Wisconsin Fundamentals of Engineering exam or that of another state.

AREAS OF STUDY

ENERGY SYSTEMS

Economic growth and development is strongly dependent upon the development and conversion of energy resources. Assurance that supplies can meet demands without excessive monetary and environmental costs will depend upon political, economic, and technological decisions. But, in any case, the key to solving the technical problems is engineering the technological development of new and better energy conversion processes and systems. The courses offered in the energy area provide a most up-to-date background for the design of traditional energy systems and for design, research, and development of new systems.

MANUFACTURING SYSTEMS

Manufacturing engineering is that specialty which requires such education and experience to understand, apply, and control engineering procedures and methods of production of industrial commodities and products. It requires the ability to plan the practices of manufacturing, to research and develop the tools, processes, machines, materials and equipment and to integrate the facilities and systems for producing quality products with optimal expenditures. The courses, including manufacturing processes, material processing, manufacturing system and reliability, offered in this area have the aim of preparing the student to face the challenges of rapidly changing technologies present in the modern manufacturing environment.

MECHANICAL SYSTEMS

This area provides the students with the theoretical, computational, and experimental tools that are necessary for the detailed analysis and design of mechanical systems including machine elements such as linkages, gears, and other power transmission components, precision tools, and machinery, etc. The courses offered in this area enable the student to understand the rationale and methodology of the overall design process of mechanical systems, proceeding from the conceptualization stage through the detailed design and implementation phases.

MECHANICAL ENGINEERING MINOR

The Department of Mechanical Engineering offers a minor in mechanical engineering to all undergraduate students in the university except those students in mechanical engineering. Completion of the minor will be noted on the student's transcript if the following requirements are met:

Thirty hours including the following courses or their equivalents: MEEN 2110, MEEN 2120, MEEN 2130, MEEN 2460, MEEN 3220, MEEN 3250, MEEN 3210, MEEN 3310, MEEN 3330 or MEEN 3340, and two (2) MEEN electives. The program as a whole must have departmental approval and be completed with a C average. Interested students should consult with the department in order to develop an acceptable program. At least 15 credit hours **must** be taken at Marquette University.

FIVE YEAR B.S./M.S. PROGRAM

This program allows students to receive a bachelor of science degree and a master of science degree in mechanical engineering in just five years. Only the thesis option is available with this program. Qualified students (3.500/4.000 GPA) who are enrolled in the Mechanical Engineering Department at Marquette University may apply for admission to this program during their undergraduate junior year. Students must submit an application to the Graduate School, indicate their interest in the five year program, and meet all other admission criteria as stated in the Application Requirements section. (GRE test scores are not required.) See Mechanical Engineering section of *Graduate School Bulletin* for details.

TABLE OF ELECTIVE COURSES

COURSES	Areas of Study		
	Energy Systems	Manufacturing	Mechanical Systems
MEEN 2402 Engineering Economy	√	√	√
MEEN 4220 Intermediate Dynamics		√	√
MEEN 4230 Intermediate Mechanics of Materials			√
MEEN 4240 Polymers and Polymer Composites		√	√
MEEN 4245 Fatigue and Fracture Mechanics			√
MEEN 4250 Design of Machine Elements 2			√
MEEN 4265 Intermediate Finite Element Methods	√		√
MEEN 4270 Physical Systems Modeling			√
MEEN 4275 Mechatronics		√	√
MEEN 4310 Internal Combustion Engines	√		
MEEN 4330 Optics, Lasers, and Spectroscopy in Engineering	√		
MEEN 4350 Transport Phenomena	√		
MEEN 4360 Intermediate Thermodynamics	√		
MEEN 4410 Experimental Design	√	√	√
MEEN 4420 Failure Analysis			√
MEEN 4430 Powder Metallurgy		√	
MEEN 4440 Processing and Forming of Materials		√	
MEEN 4450 Mechanical Behavior of Materials			√
MEEN 4475 Ergonomics		√	
MEEN 4485 Welding Engineering		√	
MEEN 4570 Introduction to Biomaterials Science and Engineering			√
MEEN 4930 Special Topics in Mechanical Engineering:	√	√	√
MEEN 4931 Topics in Mechanical Engineering:	√	√	√

NON-ENGINEERING MINORS

Students wishing to achieve a minor in business administration, mathematics or computer science should follow the guidelines below. In general, if any other major or minor program is desired, students should consult the appropriate area in the *Undergraduate Bulletin* for guidelines and requirements.

BUSINESS ADMINISTRATION MINOR

Completion of the minor will be noted on a student's transcript if the following requirements are met:

1. Required Courses		Hours
ECON 2003	Principles of Microeconomics	3
ECON 2004	Principles of Macroeconomics	3
ACCO 2030	Financial Accounting	3
ACCO 2031	Managerial Accounting	3
BUAD 1002	Computer Literacy in Business ^a	0
MANA 2028	Business and Statistics ^b	3
FINA 3001	Financial Management	3
MANA 3001	Organizational Behavior ^c	3
MARK 3001	Introduction to Marketing ^c	3
Total		24

NOTES:

- a. GEEN 1130, 1230, 1131 or BIEN 1120 will substitute for this requirement.
- b. MEEN 2426 or MATH 4720 can substitute for MANA 2028.
- c. Electrical engineering students may utilize either MANA 3001 or MARK 3001 as an EECE/Technical elective, or COEN/technical elective.

2. A C or better grade must be earned in each course.

Careful planning with an academic adviser can minimize the number of additional hours beyond the normal graduation requirements to 15-21 hours depending on the degree program.

MATHEMATICS

Students in engineering may obtain a minor in mathematics by completing the following course requirements with a grade of C or better in each: MATH 1450, MATH 1451, MATH 2450, MATH 2451, plus nine additional hours of upper division MATH courses. Overload hours can be minimized by consultation with an academic adviser.

PHYSICS

Students in engineering may obtain a minor in physics by completing the following course requirements with a grade of C or better in each: PHYS 1003 or 1013 and PHYS 1004 or 1014, plus 12 additional hours of upper division PHYS courses. Students who take ELEN 3110 or ELEN 3120 may not take PHYS 4031 or PHYS 4032 to satisfy the physics minor requirements; both ELEN 3110 or ELEN 3120 count towards the upper division PHYS course requirements.

COURSE DESCRIPTIONS

GENERAL ENGINEERING (GEEN)

GEEN 1100. Introduction to Engineering 1 sem. hr.

Individual departments provide lectures and prepare laboratory experiences intended to acquaint students with various engineering majors in the college. This course is designed to provide students with information that will allow students to select a major as well as for students to affirm their decision. The course covers civil and environmental, electrical and computer, mechanical and industrial engineering careers. *Prereq: Enrolled in Engineering*

GEEN 1110. Introduction to Engineering Problem Solving 2 sem. hrs.

Students are introduced to the engineering profession from a design and problem solving perspective. The design process is introduced along with creativity and creative techniques for finding solutions. Students learn team building techniques and compete in problem solving ventures designed to enhance their engineering experience. Writing and presentation skills are also introduced. *Prereq: Enrolled in Engineering*

GEEN 1120. Introduction to Graphics for Engineers 1 sem. hr.

Students learn to visualize geometric information and graphically communicate engineering ideas in three dimensional space. Students are exposed to graphic science and application of computer-aided design software to engineering. Conventional practices are discussed along with the application of geometric data bases to design activities and problem solving. *Prereq: Enrolled in Engineering*

GEEN 1130. Introduction to Engineering Computing 1 sem. hr.

An introduction to computer programming using a structured computer language. Includes data types, data structures, control structures and design methodologies. Laboratory experience introduces students to programming computers to solve engineering problems. *Prereq: Enrolled in Engineering*

GEEN 1131. Introduction to MATLAB 1 sem. hr.

Provides freshmen EECE students with an introduction to a widely used engineering tool through hands-on experience. Engineering problems will be presented and students will learn how to model the problems' solutions using MATLAB. *Prereq: Enrolled in Engineering*

GEEN 1200. Engineering Discovery 1 3 sem. hrs.

This course introduces the student to the practice of multidisciplinary systems engineering and engineering problem solving. Professionalism, teamwork, and technical communication are stressed. The Engineering System Investigation Process (modeling, analysis, and measurement) is applied to fundamental electrical, mechanical, fluid, thermal, and electromechanical systems using MATLAB and LabView. Elementary computer programming is developed. The Engineering Design Process and the role graphical communication - visualization, sketching, and computer graphics - plays in that process is studied. Students become proficient in the use of a three-dimensional computer graphics software. Offered in fall term.

GEEN 1210. Engineering Discovery 2 3 sem. hrs.

Students, working in small teams, apply the Engineering System Investigation Process to actual multidisciplinary products, systems, or processes. Students develop broad technical understanding, as well as in-depth technical knowledge in selected aspects, and also come to appreciate the manufacturing and materials choices, the design decisions, and the business and human-values aspects of the chosen product, system, or process. Internet-based documentation and presentation are emphasized. In addition, engineering computing using MATLAB and LabVIEW, along with computer programming, to solve common multidisciplinary engineering problems is studied. Offered in spring term. *Prereq: GEEN 1200.*

GEEN 1220. Graphical Tools for Design Communication 2 sem. hrs.

Visualization, representation, and communication of spatial objects and assemblies. Project-oriented, computer-based exercises focus on generating models of parts and assemblies and drawing of parts and assemblies. Offered spring term. *Prereq: Enrolled in Engineering*

GEEN 1230. Computational Tools for Problem Solving 2 sem. hrs.

The design of computer-based strategies to solve engineering problems. Standard structured processes for different problem types are identified and then, in exercises, concatenated to solve more complex problems. Both the communication of solution strategy (pseudocode, flowchart), together with its realization and verification in tested code are emphasized. Offered fall term. *Prereq: Enrolled in Engineering*

GEEN 2952. Engineering Orientation Colloquium 0 sem. hrs.

No credit. A one-hour-per-week series of lectures, discussions and engineering speakers to assist beginning sophomores to define more clearly their professional goals by acquainting them with diversified career options available to engineers. Topics include: engineering career exploration and development; cooperative education and internships; and job search, resume writing and interviewing techniques. All sophomores and transfer students are required to attend. *Prereq: Enrolled in Engineering. SNC/UNC grade assessment.*

BIOMEDICAL ENGINEERING (BIEN)

Chairperson and Professor: Ropella
Professor: Brower (Emeritus), Harris, Hendee, Jeutter, Josse, Seitz, Winters
Adjunct Professor: Battocletti, Cowley, Hoffman, Hudetz, Hyde, Larson, Madden, Merritt, Pintar, Sarna, Schwab, Smith, Toth, Wartier, Wertsch, Yoganandan
Associate Professor: Brown, Cariapa, Clough, Goldberg, Krenz, Marklin, Nagurka, Olson, Riedel, Scheidt, Schmit, Silver-Thorn
Adjunct Associate Professor: Greene, Jodat, Schlager, Schmeling
Assistant Professor: Audi, Beardsley, Gilat-Schmidt, LaDisa

Adjunct Assistant Professor: Ackman, Bandettini, Boskamp, Butson, DeYoe, Donnell, Hause, Hubbard, Leibenthal, Liu, Lyon, Marks, Merker, Molthen, M. Johnson, Ninomiya, P. Smith, Patel, Piacsek, Prieto, Rickaby, Schmainda, Shi, Stemper, Street, Ulmer, Wang
Research Assistant Professor: Johnson

BIEN 1100. Introduction to Biomedical Engineering Methods 1 2 sem. hrs.

Introduction to biomedical engineering design and problem solving using. Key elements include physiologic signals and data acquisition, instrumentation, graphics, measurement and error, teamwork and decision-making. Problem-solving elements will be applied to real-world biomedical problems introduced by practicing biomedical engineers as well as faculty.

BIEN 1110. Introduction to Biomedical Engineering Methods 2 2 sem. hrs.

Continuation of BIEN 1100. Key elements include modeling, fluid mechanics, rehabilitation engineering, and entrepreneurship. Problem-solving and design elements are applied to real-world biomedical problems introduced by practicing biomedical engineers as well as faculty. *Prereq: BIEN 1100.*

BIEN 1120. Introduction to Computing for Biomedical Engineers 2 sem. hrs.

Introductory hands-on experience in computer programming, MATLAB, and Solid Modeling and CAD for biomedical engineers. Involves learning linear programming in C and creating flow-charts to solve biomedical applications. Computing topics will include syntax, data types, control flow and algorithm development. Biomedical applications include analyzing physiological signals, biological event detection, and biomechanical analysis. Students learn how to use MATLAB to solve biomedical applications. Solid modeling and CAD will be studied in the context of biomedical engineering design. Laptop required.

BIEN 2100. Statistics for Biomedical Engineering 1 sem. hr.

Numerical and graphical summary of biomedical data and the use of statistics in problem solving for a variety of case studies in biomedical research, medical device design and clinical trials. *Prereq: MATH 1450.*

BIEN 2300. Biomedical Circuits and Electronics 4 sem. hrs.

An experience in electrical circuits (AC and DC), electronic devices (Junction, Transistor, Operational Amplifier) bridges, digital circuits and Boolean implementation, combinational and sequential logic, memories. Use of P-Spice software. Analysis and design. *Prereq: PHYS 1004 or PHYS 1014.*

BIEN 2400. Medical Device Design Constraints 1 sem. hr.

Students learn about legal, ethical, regulatory, economic, environmental, cultural, and social constraints that affect the design of medical devices. Students identify relevant, applicable design constraints and understand the impact of these constraints on the design process and the project schedule.

Prereq: Soph. stndg. BIEN major, or cons. of instr.

BIEN 3200. Computer Applications in Biomedical Engineering 3 sem. hrs.

Design and implementation of computer techniques for the acquisition and analysis of biomedical data and the modeling of physiologic phenomena. Emphasis on physiological data acquisition, statistical description of physiological data, time domain and frequency domain methods for physiological signal conditioning and processing, and numerical methods for quantitative interpretation of physiological data using C programming language.

Prereq: BIEN 1110 or equiv.

BIEN 3300. Signals and Systems for Biomedical Engineering 3-4 sem. hrs.

Mathematical models of continuous-time signals and systems are studied in this course. The time domain viewpoint is developed for linear time invariant systems using the impulse response and convolution integral. The frequency domain viewpoint is also explored through the Fourier Series and Fourier Transform. Basic filtering concepts including simple design problems are covered. Application of the Laplace transform to block diagrams, linear feedback, and stability including Bode plots are discussed. The sampling theorem, the z-transform, and the Discrete Fourier Transform are introduced. Examples of electrical, mechanical, and biomedical signals and systems are used extensively throughout the course. Offered both terms. 3 hrs. lec.

Prereq: ELEN 2020 with minimum grade of C and MATH 2451; or BIEN 2300 with minimum grade of C and MATH 2451; or ELEN 2020 with minimum grade of C and MATH 2455; or BIEN 2300 with minimum grade of C and MATH 2455.

BIEN 3310. Control Systems for Biomedical Engineering 3 sem. hrs.

Provides an introduction to the principles of control systems theory for biomedical engineers. Mathematical techniques to characterize and design control systems will be studied in the context of physiological, bioelectrical, biochemical and bio-mechanical systems. Topics include frequency and time-domain modeling of physiological control systems, feedback, stability, steady-state error, design, root-locus, state-space techniques, and nonlinear control. Simulation using MATLAB and Simulink will be used to provide hands-on experience in the design of biomedical control systems.

Prereq: BIEN 3300.

BIEN 3400. Clinical Issues in Biomedical Engineering Design 1 sem. hr.

Develops clinical literacy in areas including medical terminology, working with medical professionals, professional conduct in the clinical environment, operating room workflow, and the technical needs of surgeons, nurses, dentists, and others. Students observe procedures in the clinical environment and learn to listen, ask questions, and identify problems, unmet needs and opportunities for new product development. Students participate in field trips to obtain hands-on experience with various medical and dental devices. A project proposal for a new medical device or technology is required at the end of the course.

Prereq: BIEN major and jr. stndg; or cons. of instr.

BIEN 3991. Co-op Work Period 1 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. SNC/UNC grade assessment.

BIEN 3992. Co-op Grading Period 1 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. A nominal fee is charged for registration for Work Periods. No tuition is charged for Grading Periods. S/U grade assessment.

BIEN 3993. Co-op Work Period 2 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994 etc. Fee. SNC/UNC grade assessment.

BIEN 3994. Co-op Grading Period 2 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. A nominal fee is charged for registration for Work Periods. No tuition is charged for Grading Periods. S/U grade assessment.

BIEN 4220. Embedded Biomedical Instrumentation 3 sem. hrs.

Fundamentals of digital circuit design and analysis and the application to embedded biomedical instrumentation. Topics include microprocessor principles and programming and system design constraints for medical electronics. Laboratory will provide applications of concepts introduced in class. Offered spring term. *Prereq: BIEN 2300.*

BIEN 4230. Intelligent Biosystems 3 sem. hrs.

Use of emerging tools in systems biology and soft computing to explore how biosystems with highly distributed "intelligence" are designed to adapt to self- and environmentally-induced perturbations. Students obtain a basic understanding of key soft computing tools and use fuzzy expert system models. Applications to smart health care monitoring and future product design will be explored.

Prereq: Jr. stndg. and BIEN 4700.

BIEN 4280. Biocomputers Design Lab 1 3 sem. hrs.

Hands-on experience in software design and validation, microprocessors, computer architecture, real-time computing, embedded software, graphical user interface and networking. An emphasis on medical devices with embedded software and hardware. Offered fall term. *Prereq: BIEN 2300, BIEN 4220, BIEN 3300, and BIEN 3200.*

BIEN 4290. Biocomputers Design Lab 2 3 sem. hrs.

Continuation of BIEN 4280 with emphasis on high performance computing in workstation environments. Offered spring term. *Prereq: BIEN 4280.*

BIEN 4320. Biomedical Instrumentation Design 3 sem. hrs.

Problems in instrumentation relating to physiological measurements in the laboratory and clinic. Electronic devices for stimulus as well as measurement of physiological quantities. Design of actual instruments. Features include mechanical design, accessory design and safety requirements.

Prereq: BIEN 2300 and BIEN 3300; or ELEN 3030 and ELEN 3020.

BIEN 4380. Bioelectronics Design Lab 1 3 sem. hrs.

Understanding the principles of operation, safe operating procedures and methods of medical instrument selection. Design of experiments to measure physiological parameters. Typical experiments include: electrical safety; myography; force measurement; operational amplifier characterization; active filter; respiration monitoring. Actual medical instruments used under approximate clinical conditions. Report writing. 2 hrs. lec., 3 hrs. lab.

Prereq: EECE 2015, EECE 2035, ELEN 3030.

BIEN 4390. Bioelectronics Design Lab 2 3 sem. hrs.

Design of circuits used in research and clinical instrumentation. Experiments include the design, fabrication and evaluation of specific circuits. Typical projects include circuits used for: patient isolation from electrical hazard, measurement of heart rate, multiplexing and demultiplexing and analog to digital conversion. Design projects incorporating microprocessors are also included. Students required to submit reports. 2 hrs. lec., 3 hrs. lab. *Prereq: BIEN 4380 and EECE 3015.*

BIEN 4400. Transport Phenomena 3 sem. hrs.

Applications of mass, momentum, and mechanical energy balances to biomedical fluid systems. Study of physiological phenomena with an emphasis on cardiovascular systems and blood rheology.

Prereq: MEEN 2120, CEEN 2122, or cons. of instr.

BIEN 4410. Applied Finite Element Analysis 3 sem. hrs.

This course will introduce the finite element solution method for linear, static problems. The course will include calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Although the course will emphasize structural mechanics, heat transfer and fluid mechanics applications in finite element analysis also will be discussed. Computer assignments will include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).

Prereq: Sr. stndg., BIEN 1110 and CEEN 2130; or Sr. stndg., CEEN 2130, and GEEN 1220.

BIEN 4420. Introduction to Biomaterials Science and Engineering 3 sem. hrs.

This course is designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities, and restoring lost function. The science aspect of the course encompasses topics including characterization of material properties, biocompatibility, and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects will allow students to focus and gain knowledge in an area of biomaterials engineering that they are interested in.

Prereq: MEEN 2460 or cons. of instr.

BIEN 4480. Biomechanics Design Lab 1 3 sem. hrs.

Intended for those students pursuing the Biomedical Engineering Biomechanics option. The application of principles of engineering mechanics, data acquisition and basic electronics in the design and utilization of biomechanical instrumentation. Principles of transduction, mechanics, sampling theory, strain, temperature, and flow measurement as applied to biomechanical systems. A background in data acquisition, electrical safety, operational amplifier and bridge circuits, and measurements is provided. Experiments investigate biomechanics of the musculoskeletal and cardiovascular systems and include design content. Report writing. 2 hrs. lec., 3 hrs. lab.

Prereq: BIEN 2300, MEEN 2120, and CEEN 2130.

BIEN 4490. Biomechanics Design Lab 2 3 sem. hrs.

Provides students with experience in the design and implementation of appropriate experimental procedures to analyze biomechanical problems. Students will become familiar with various types of advanced transducers which will be used in conjunction with data acquisition workstations to obtain thermal, flow, strain, and related physiological data from biomechanical systems. Topics include mechanical properties of active muscle; analysis of human motion; postural stability; thermal regulation; cardiovascular mechanics; stress distribution in skeletal system; and comparison of static and dynamic biomechanical responses to load. 2 hrs. lec., 3 hrs. lab.

Prereq: BIEN 4480.

BIEN 4500. Medical Imaging Physics 3 sem. hrs.

Students learn how light, X-rays, radiopharmaceuticals, ultrasound, magnetic fields, and other energy probes are generated and how they interact with tissues and detectors to produce useful image contrast. Practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness will be addressed. Emphasis is placed upon diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities. *Prereq: PHYS 1004 or PHYS 1014.*

BIEN 4510. Image Processing for the Biomedical Sciences 3 sem. hrs.

This course serves as an introduction to biomedical image processing. Topics explored included the human visual system, spatial sampling and digitization, image transforms, spatial filtering, Fourier analysis, image enhancement and restoration, non-linear and adaptive filters, color image processing, geometrical operations and morphological filtering, image coding and compression image segmentation, feature extraction and object classification.

Applications in diagnostic medicine, biology and biomedical research are emphasized and presented as illustrative examples.

Prereq: MATH 1450 and MATH 1451 or MATH 1455; knowledge of C programming; or cons. of instr.

BIEN 4600. Neural Engineering 3 sem. hrs.

Basic principles of neural engineering, properties of excitable tissues, quantitative models used to examine the mechanisms of natural and artificial stimulation. Basic concepts for the design of neuro-prosthetic devices for sensory, motor and therapeutic applications. Design issues including electrode type, biomaterials, tissue response to stimulating electrodes and stimulus parameters for electrical stimulation and artificial control. Examples of how engineering interfaces with neural tissue show increasing promise in the rehabilitation of individuals of neural impairment.

Prereq: PHYS 1004 or PHYS 1014.

BIEN 4610. Introduction to Rehabilitation Robotics 3 sem. hrs.

Presents the fundamentals of robotics as it is applied to rehabilitation engineering. Specific topics include: the fundamentals of analysis and design of robot manipulators with examples and mini-projects taken from rehabilitation applications pertaining to robotic therapy devices and personal assistants. Additional topics include: overview of rehabilitation robotics field, human-centered design of rehabilitation robots issues and challenges, robot configurations, rigid motions and homogeneous transformations, Denavit-Hartenberg representation, robot kinematics, and inverse kinematics, Euler-Lagrange equations, trajectory generation, sensors, actuators, independent joint control, force control and safety.

Prereq: Jr. stndg.

BIEN 4620. Rehabilitation Science and Engineering 3 sem. hrs.

Introduces rehabilitation science as the study of tissue and functional change, including: overview of key human sensory modalities and neuromotor systems in the context of functional capabilities and human performance metrics; review of spontaneous recovery mechanisms in response to various types of tissue trauma; review of roles of genetics and gene transcription networks in pathology and functional recovery prognosis; and the concept of rehabilitative assessment and therapeutic interventions as an optimization problem. Also focuses on the use of assistive technology to enhance access to independent living and to optimize the delivery of rehabilitative health care services. Includes rehabilitation biomechanics of physical interfaces, use of access and usability engineering in product design and innovative assessment and intervention strategies for neurorehabilitation.

Prereq: BIEN 2300 or equiv.

BIEN 4630. Rehabilitation Engineering: Prosthetics, Orthotics, Seating and Positioning 3 sem. hrs.

Presents an overview of biomedical engineering as it applies to Rehabilitation Engineering, specifically, the design and prescription of prosthetic limbs, orthotic devices, and seating and positioning systems. Topics include: medical terminology, musculoskeletal anatomy, muscle mechanics, soft tissue mechanics, gait/locomotion, amputation surgery, lower extremity prosthetics, lower extremity orthotics, hand function, electromyography, upper extremity prosthetics, upper extremity orthotics, seating and positioning, and assistive devices.

Prereq: MEEN 2120 or CEEN 2122.

BIEN 4640. Bioengineering of Living Actuators 3 sem. hrs.

Overview of muscle tissue as a living actuator from the perspective of engineering design, systems biology, muscle modeling and adaptive control.

Prereq: BIEN 4700, BIEN 3300.

BIEN 4700. Systems Physiology 3 sem. hrs.

Analyses of the underlying physiologic and bioengineering aspects of the major cell and organ systems of the human from an engineer's point of view. Classic physiologic approaches used to introduce topics including cell functions, nervous system, nerve, muscle, heart, circulation, respiratory system, kidney, reproduction and biomechanics. Design problems including models of cell-organ-system function and problems in biomechanics illuminate topics covered. Computer techniques and relevant instrumentation are incorporated. Experts on related topics are invited to speak as they are available.

Prereq: Jr. stndg.

BIEN 4710. Analysis of Physiological Models 3 sem. hrs.

Development of continuous (compartmental), and distributed-in-space-and-time mathematical models of physiological systems and molecular events. Analytical and numerical methods for solving differential equations of the initial and boundary value types. Simulation of model response, and estimation of model parameters using linear and nonlinear regression analysis. *Prereq: Jr. stndg. and MATH 2451; or jr. stndg. and MATH 2455.*

BIEN 4720. Cardiopulmonary Mechanics 3 sem. hrs.

Examination of the physiological behavior of the cardiovascular and pulmonary systems from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via experimental models.

Prereq: BIEN 4700, which must be taken concurrently, or equiv.; and BIEN 4400, which must be taken concurrently, or equiv.; or cons. of instr.

BIEN 4920. Principles of Design 3 sem. hrs.

Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). Offered fall term. 2 hrs. lec., 2 hrs. lab.

Prereq: Sr. stndg.; co-op students, jr. stndg. Cross-listed with COEN 4920, ELEN 4920 and MEEN 4920.

BIEN 4931. Topics in Biomedical Engineering 1-3 sem. hrs.

Course content announced prior to each term. Students may enroll in the course more than once because subject matter changes. Possible topics include biomechanics, experimental methods, neuroanatomy, telemetry, etc. *Prereq: Jr. stndg.*

BIEN 4991. Co-op Work Period 3 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992, etc. Fee. SNC/UNC grade assessment.

BIEN 4992. Co-op Grading Period 3 1 sem. hr. Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. A nominal fee is charged for registration for Work Periods. No tuition is charged for Grading Periods. S/U grade assessment.

BIEN 4993. Co-op Work Period 4 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994, etc. Fee. SNC/UNC grade assessment.

BIEN 4994. Co-op Grading Period 4 1 sem. hr. Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. A nominal fee is charged for registration for Work Periods. No tuition is charged for Grading Periods. S/U grade assessment.

BIEN 4995. Independent Study in Biomedical Engineering 1-4 sem. hrs.

Undergraduate independent study project of either a theoretical or experimental nature.
Prereq: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.; or sr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.

BIEN 4998. Senior Design Project 3 sem. hrs. Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. Offered Spring semester. 2 hrs. lec., 2 hrs. lab.
Prereq: BIEN 4920. Cross-listed with COEN 4998, ELEN 4998 and MEEN 4998.

CIVIL AND ENVIRONMENTAL ENGINEERING (CEEN) and (CEMA)

Chairperson: Wenzel

Director of Graduate Studies: Heinrich

Professor Emeriti: Faherty, Zanon

Professor: Federle, Foley, Heinrich, Karshenas,

Melching, Switzenbaum, Vinnakota, Zitomer

Adjunct Professor: Kuemmel

Associate Professor: Crandall, Crovetti, Drakopoulos,

Wenzel

Adjunct Associate Professor: Sonntag, Vogel

Assistant Professor: Wan

Adjunct Assistant Professor: Dobersek, Meus

Civil Engineering (CEEN)

CEEN 2110. Statics 3 sem. hrs. Fundamentals of forces and force systems. Internal and external forces. Support reactions. Definition of a free-body diagram (FBD). Emphasis on development of FBD-drawing skills. Moment of a force. Force system resultants. Vector methods in two and three dimensions. Equilibrium analysis of particles and rigid bodies. Truss analysis by methods of joints and sections. Analysis of simple frames and machines. Analysis of friction. Centroids of composite areas and volumes. Resultants of distributed loads. Offered each term.
Prereq: MATH 1451 or MATH 1455, which may be taken concurrently. Same as MEEN 2110.

CEEN 2120. Dynamics 3 sem. hrs. Fundamentals of motion of particles and rigid bodies. Application of Newton's laws. Principles of position, velocity, and acceleration. Use of work-energy and impulse-momentum methods. Introduction to vibrations. Offered each term. *Prereq: CEEN 2110 or MEEN 2110. Same as MEEN 2120.*

CEEN 2122. Statics and Dynamics 4 sem. hrs. Fundamentals of forces, force systems and their application to static and dynamic bodies and systems of particles emphasizing vector methods in two and three dimensions. Equations of equilibrium. Friction, applications of Newton's laws, energy and momentum methods. Offered spring terms.
Prereq: MATH 1451 or MATH 1455, which may be taken concurrently. Same as MEEN 2122.

CEEN 2130. Mechanics of Materials 3 sem. hrs. Concepts of stress, strain and deflection. Factor of safety. Mechanical properties of materials. Stress and deformation calculations for cases of axially loaded rods, torsion of circular shafts, beam bending and combined loading. Horizontal shear connectors in built-up beams. Area moment of inertia. Parallel-axis theorem. Introduction to beam design. Stress concentration. Stress transformation and principal stress calculation by Mohr's circle. Statically indeterminate analysis. Elastic buckling of columns. Offered each term. *Prereq: CEEN 2110 or MEEN 2110. Same as MEEN 2130.*

CEEN 2310. Elementary Surveying 3 sem. hrs. Fundamental concepts and theory of engineering measurements; adjustment and use of instruments; computations; errors; measurement of distance, difference in elevation, angles and directions; route surveying, construction surveys. Probability concepts and statistical analysis of field data. Offered fall term. 2 hrs. lec., 3 hrs. lab.

CEEN 3150. Mechanics of Fluids 3 sem. hrs. Fundamental conservation laws of mass, momentum, and energy. Properties of fluids, hydrostatics, flow of real fluids in closed and open systems, dynamic similarity, dimensional analysis, compressible flow, and potential fluid flow. Offered each term. Same as MEEN 3320.

CEEN 3160. Geotechnical Engineering 3 sem. hrs. Fundamental properties and the engineering characteristics of soil as a particulate mass aggregate. Origin, the formation and the development of soil deposits, the physical and hydraulic properties and the methods of predicting the behavior of soils for engineering applications are studied. Properties are investigated in the laboratory and reports are required. Offered fall term. 2 hrs. lec., 2 hrs. lab.
Prereq: CEEN 2130 or MEEN 2130, which may be taken concurrently.

CEEN 3210. Hydraulic Engineering 3 sem. hrs. Fundamentals and applications of hydrostatics and hydrodynamics including pressurized pipe flow and pipeline network design, open channel flow, and sewer design, pump selection and flow measurement. Laboratory assignments and demonstrations. Offered spring and summer terms. 2 hrs. lec., 2 hrs. lab. *Prereq: CEEN 3150 or MEEN 3320.*

CEEN 3220. River Engineering 3 sem. hrs. Basic principles of open-channel hydraulics, flow resistance, gradually-varied flow, rapidly-varied flow, hydrologic and hydraulic flood routing, and river restoration/ naturalization. *Prereq: CEEN 3210.*

CEEN 3320. Behavior and Properties of Engineering Materials 3 sem. hrs. Introduction to the characteristic properties and the fundamental phenomenological behavior of the materials used by engineers with emphasis on steel, concrete, wood, and asphalt. Laboratory experiment and testing is used to give knowledgeable perception of the behavior when materials are subjected to various loads. Probability concepts and statistical analysis of experimental data. Offered spring term. 2 hrs. lec., 2 hrs. lab. *Prereq: CEEN 2130 or MEEN 2130, which may be taken concurrently.*

CEEN 3410. Structural Analysis 3 sem. hrs. Determining the loads that act on structures and load combinations. Basic concepts in structural analysis of determinate beams, trusses, and frames. Deflections of determinate beams by moment area and conjugate beam methods. Development of basic virtual work concept to obtain deformations in determinate trusses, beams, and frames. Introduction to the solution of indeterminate structures by using the method of superposition. Influence lines for determinate beams. *Prereq: CEEN 2130 or MEEN 2130.*

CEEN 3430. Steel Design 1 3 sem. hrs. Interpretation of current codes as related to the physical behavior of steel structures. Design of structural steel members: tension, compression, flexural and beam-columns. Introduction to design of connections. Offered fall term.
Prereq: CEEN 3410.

CEEN 3440. Reinforced Concrete Design

3 sem. hrs.

Fundamental concepts of reinforced concrete theory and design. Use of current design code for the analysis and design of basic structural members; strength design for flexure, shear and development of reinforcement. Offered fall term.

Prereq: CEEN 3410.

CEEN 3510. Environmental Engineering

3 sem. hrs.

Introduction to environmental engineering with a focus on the water environment. Topics include water quality, water resources, water supply, municipal water and wastewater systems, air quality, and solid and hazardous waste management. Offered fall term. *Prereq: Jr. stndg.*

CEEN 3610. Transportation Engineering

3 sem. hrs.

Emphasis on forecasting methodologies -- applications to transportation. Use of spreadsheets for simple and multiple linear regression, statistical charts. Airport airside systems based on FAA guidelines. Road user and vehicle characteristics, geometric design of roadways including horizontal and vertical alignment and cross-sectional elements. Signalized intersections. Emphasis on technical-report writing. Offered spring term. *Prereq: Jr. stndg.*

CEEN 3615. Highway Planning and Design

3 sem. hrs.

Emphasis on highway planning, alternate highway alignments and alternate evaluation. Also geometric design of highways including horizontal and vertical alignment, cross-section design. Projects on detailed design of reverse curves (plan and profile views); intersection design; cross-section and earthwork quantities. Legal aspects of engineering. Use of American Association of State Highway and Transportation Officials design guidelines. Offered spring term. 2 hrs. lec., 2 hrs. lab.

Prereq: CEEN 3610 or cons. of instr.

CEEN 3620. Highway Interchange Design

3 sem. hrs.

Planning, analysis, design and operational analysis of highway interchanges. Determination and adaptability of interchange types for freeway to freeway and service interchanges. Offered alternate fall terms. *Prereq: CEEN 3610.*

CEEN 3625. Urban Street Design

3 sem. hrs. Planning consideration, highway system components, design elements, including horizontal and vertical alignment, cross section elements, sight distance, intersections, parking, one way streets, mass transit and bicycle considerations.

Prereq: CEEN 3610.

CEEN 3630. Airport Planning and Design

3 sem. hrs.

Introduction to airport planning and design parameters, aircraft characteristics, payload versus range, runway length requirements, air traffic control, wind analysis, airside capacity and delay, airside separation criteria, terminal analysis and delay, airport access flow and capacity, ramp charts. Economic analysis of facility improvements. Offered fall term. *Prereq: CEEN 3610 or cons. of instr. This course is a design elective.*

CEEN 3640. Traffic Characteristics and Design

3 sem. hrs.

Components of the traffic system: vehicle and road user characteristics, geometric design and traffic controls. Intersection types, cross-section design

elements and typical dimensions. Basic variables of traffic flow, observed traffic flow values. Freeway operations. Signalized intersections: flow, capacity, level of service. Projects addressing: intersection existing conditions (traffic, geometry, signalization); approach delay; safety performance; capacity; suggestions for improvements. Use of the Highway Capacity Manual and the Highway Capacity Software. Emphasis on technical report-writing and presentation. Offered fall term.

Prereq: CEEN 3610 or cons. of instr.

CEEN 3645. Traffic Engineering

3 sem. hrs. Design, analysis and use of traffic control devices. Traffic administration, traffic flow theory, and highway capacity. An introduction to computer and traffic engineering. Offered spring term.

Prereq: CEEN 3640 or cons. of instr.

▲CEEN 3720. Decent and Affordable Housing

3 sem. hrs.

Through helping to construct a Habitat for Humanity house; through listening to and debating with guest lecturers who are helping to build housing units for low income people; and through reading and discussing books, articles, and other selected documents that focus on the problems of the central cities, the students will learn that decent and affordable housing is an issue of social justice and it can become a reality wherever there is a will to make it happen.

CEEN 3730. Engineers and Technology Through History

3 sem. hrs.

The history, including individuals and tradition, that have contributed to the development and growth of technology and engineering in the United States. Topics include: ancient and medieval engineering, early U.S. engineers, the Industrial Revolution, railroads and engineers, transportation, urban growth, and engineers of the 20th century.

CEEN 3991. Co-op Work Period 1

0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Offered every term. Fee. SNC/UNC grade assessment.

CEEN 3992. Co-op Grading Period 1

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

CEEN 3993. Co-op Work Period 2

0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994 etc. Offered every term. Fee. SNC/UNC grade assessment.

CEEN 3994. Co-op Grading Period 2

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

CEEN 4145. Advanced Strength and Applied Stress Analysis

3 sem. hrs.

Basic concepts of mechanics of deformable bodies. Two- and three-dimensional stress-strain relationships and theories of failure. Unsymmetrical bending analyses. Shear flow and shear center. Torsion of thin-walled sections (tubular and non-tubular). Composite beams. Stress concentration. Energy principles: strain and complementary energy. Castigliano's theorem. Offered fall term alternate years. *Prereq: CEEN 2130 or MEEN 2130.*

CEEN 4230. Urban Hydrology and Stormwater Management

3 sem. hrs.

Distribution and properties of waters on the earth. Concept of the hydrologic cycle, and basic principles of meteorology, precipitation, streamflow, evapotranspiration, and groundwater flow. Erosion and urban stormwater pollution. Design of urban flood protection and stormwater pollution abatement systems. Offered fall term.

Prereq: CEEN 3150, or MEEN 3320.

CEEN 4240. Water Resources Engineering

3 sem. hrs.

Surface waters, groundwater yields, probability concept in water resources design, water laws, reservoirs and dams, open channels and flow regulation, irrigation and drainage, flood damage mitigation, hydroelectric power, water resources economy and planning. Offered spring term. *Prereq: CEEN 3210.*

CEEN 4250. Groundwater Engineering

3 sem. hrs.

Physical and chemical properties and principles of groundwater. Groundwater geology and interaction with the hydrologic cycle. Groundwater movement and flow nets. Groundwater contamination.

Prereq: CEEN 3210 and CEEN 3510.

CEEN 4310. Geographical Information Systems in Engineering and Planning

3 sem. hrs.

Topics covered include: fundamentals of GIS, databases, data management, map projections, representations of spatial attributes, GIS analysis and GIS software systems such as ARC Info, ARC View, Grass. GIS use and expanded capabilities will be taught. Case studies including environmental, transportation and economic applications will be discussed. Offered spring term. *Prereq: Sr. stndg.*

CEEN 4320. Engineering Decisions Under Uncertainty

3 sem. hrs.

Application of probability and statistics to modeling, analysis and design of civil engineering systems. Topics include: probability theory, decision theory, utility theory, and simulation. Offered spring term. *Prereq: Sr. stndg.*

CEEN 4340. Urban Planning for Civil Engineers

3 sem. hrs.

Concepts and principles underlying urban planning and development. Land use, transportation, utility, community facility planning problems, procedures, and techniques. The master plan and implementation devices such as zoning, subdivision control, official mapping, capital budgeting, and urban renewal. Offered spring term.

CEEN 4350. Law for Engineers

3 sem. hrs.

Basic legal principles and awareness of typical legal questions that arise when engineers and law interact. Topics include: American judicial system, law of contracts, forms of association, construction contracts, professional liabilities of engineers, and torts. *Prereq: Sr. stndg. or cons. of instr.*

CEEN 4411. Matrix Structural Analysis

3 sem. hrs.

Introduction to symbolic and numerical linear algebra computations using commercial software. Modeling axial, bending, and torsion deformations in structural members using polynomials. Application of the principle of virtual work to compute deflections for statically determinate and indeterminate problems. Formulation of the matrix stiffness method via the principle of virtual displacements and the matrix flexibility method via the principle of virtual forces. Application of the matrix stiffness method for solving statically indeterminate structural analysis problems. Use of approximate methods of structural analysis (cantilever and portal methods) for critical evaluation of software-generated solutions. Use of commercial software for structural analysis. Offered fall term. *Prereq: CEEN 3410.*

CEEN 4431. Steel Design 2 3 sem. hrs.

Continuation of CEEN 3430. Design of steel beam-columns, continuous beams, composite beams and composite columns. Design of bolted and welded joints, connections, and sub-assemblages. Design of steel building structures. Offered spring term. *Prereq: CEEN 3430.*

CEEN 4441. Advanced Concrete and Masonry Design 3 sem. hrs.

Continuation of CEEN 3440, presenting advanced concrete theory and design: introduction to masonry design. Emphasis on code requirements and use of various design aids including computer-aided design. Design of two-way slabs and reinforced concrete structural systems. Design and layout of reinforced concrete and concrete masonry walls. Offered spring term. *Prereq: CEEN 3440.*

CEEN 4442. Prestressed Concrete Design

3 sem. hrs.

Introduction to the philosophy and concepts of prestressed concrete design. Study of the historical background, materials and methods of prestressing. Use of current code and basic principles and procedures for the design and analysis of pretensioned and post-tensioned members including calculation of loss of prestress, flexural analysis and design, shear, bond and anchorage requirements, member deflections and cable layouts. *Prereq: CEEN 3440.*

CEEN 4450. Bridge Design 3 sem. hrs.

Introduction to bridge engineering and construction including: an abbreviated history of bridge construction; bridge types; bridge nomenclature; lessons from failures; design philosophies; and the construction process. Analysis of single- and multi-span bridge superstructures using classical techniques and commercial software. Design of single-span reinforced concrete slab bridges; reinforced concrete bridge decks; and single-span slab-bridges in prestressed concrete. Offered spring term. *Prereq: CEEN 3430 and CEEN 3440.*

CEEN 4460. Foundation Engineering

3 sem. hrs.

Design of foundation members subjected to vertical and eccentric loads. The effects of soil origin and deposition and the current codes and conventions are analyzed in relation to bearing capacity and settlement of structures. *Prereq: CEEN 3160.*

CEEN 4515. Environmental Chemistry

3 sem. hrs.

Chemical stoichiometry, equilibrium, and kinetics relating to natural and engineered environmental systems. Basic concepts from organic and inorganic chemistry including oxidation-reduction reactions,

acid-base chemistry, the carbonate system, alkalinity, and acidity. Equilibrium and kinetic theories of chemical partitioning among gas, liquid and solid phases governing chemical fate and transport in the environment. Coordination chemistry describing metal-ligand interactions, precipitation, and bioavailability of materials. Offered fall term.

Prereq: Sr. stndg. and CHEM 1002.

CEEN 4520. Industrial Wastewater Management 3 sem. hrs.

Review of federal legislation and state regulations with regard to industrial wastewater management practices. Consideration of industrial process modifications and wastewater treatment options with respect to their effect on industrial user fees. Pretreatment standards and discharge permit requirements. Case studies of specific industrial applications. Offered spring term of alternate years. *Prereq: CEEN 3510.*

CEEN 4525. Treatment Plant Design and Operation 3 sem. hrs.

Review of water and wastewater characteristics, drinking water, receiving water and effluent standards. Basic design methodology and operational features of common physical, chemical and biological processes for the treatment of waters and wastewaters. Introduction to the processing and disposal of sludges and other treatment plant residuals. Offered fall term. *Prereq: CEEN 3510.*

CEEN 4530. Hazardous and Industrial Waste Management 3 sem. hrs.

Overview of hazardous waste management, disposal and soil and ground water remediation. Review of RCRA, CERCLA-SARA, TSCA and Wisconsin's NR 700 and other regulations. Definition of hazardous wastes and characterization of industrial waste stream. Chemical, physical and biological properties of hazardous wastes. Introduction to hazardous waste remediation/treatment methods and technologies. Landfills and the RCRA Land Ban regulations. Site assessments, field investigations and laboratory analytical techniques. Environmental risk assessments, cleanup objectives and waste minimization. Offered spring term alternate years. *Prereq: Sr. stndg. or cons. of instr.*

CEEN 4535. Environmental Engineering Microbiology 3 sem. hrs.

Includes microbiological and biochemical properties of microorganisms important in environmental engineering practice. General fundamentals of environmental microbiology and their application to drinking water treatment and distribution, water pollution control, and natural systems. Offered alternate spring terms. *Prereq: CEEN 3510 or cons. of instr.*

CEEN 4540. Municipal Solid Waste Management 3 sem. hrs.

Introduction to municipal solid waste management and hazardous wastes associated with municipal solid wastes. Emphasizes the relationship between the properties of wastes, the techniques and hardware used for waste handling and processing and the ultimate disposal (containment) of waste and other residual materials. Covers remediation of orphaned landfills. Examines the design of systems for the management and disposal of solid and hazardous wastes subject to economic factors, safety, reliability and ethical and social implications. Offered spring term alternate years. *Prereq: CEEN 3510.*

CEEN 4545. Air Pollution Engineering

3 sem. hrs.

Topics covered include: public health aspects of air pollution, stationary and traffic sources, chemistry of air pollutants and aerosols, air pollution meteorology, dispersion modeling, regulations and criteria regarding pollution emissions and pollution control engineering. *Prereq: Jr. stndg.*

CEEN 4650. Pavement Design 3 sem. hrs.

Study of the behavior and properties of pavements with emphasis on asphalt and Portland cement concrete pavements. Structural design of pavement systems using current design methods. Use of computer programs and their application in the design of pavements. Offered fall terms.

CEEN 4660. Pavement Management

3 sem. hrs.

Study of the performance of pavement systems based on design, traffic and maintenance activities. Methods for evaluating in-service pavements including condition surveys, nondestructive testing and destructive testing. Development of maintenance strategies for highway and airfield pavements and life-cycle cost analysis of these strategies. Offered spring term. *Prereq: CEEN 4650 or cons. of instr.*

CEEN 4670. Advanced Transportation Materials 3 sem. hrs.

Advanced study of materials used for constructing transportation facilities, with particular emphasis on subgrade soils, bound and unbound aggregates, hot mix asphalt and Portland cement concrete. Laboratory test methods and analytical models used for characterizing transportation materials will be examined. Variations in material properties as a result of loading and environmental factors will be addressed. Offered fall terms. *Prereq: CEEN 2320 and CEEN 3160.*

CEEN 4710. Engineering Fundamentals Review 1 sem. hr.

Review of basic science, mathematics, engineering science and economics. Offered every term. S/U grade assessment. *Prereq: Sr. stndg. Same as MEEN 4590.*

CEEN 4715. Sustainable Engineering

3 sem. hrs.

Overview of sustainable engineering principles including environmental, economic and social equity issues. Tools, such as mass and energy balances and life cycle assessment will be covered. Other topics include global warming, green house gases, green engineering, clean manufacturing, and sustainable management of energy and natural resources. *Prereq: CEEN 3510 or cons. of instr.*

CEEN 4740. Health, Environment, and Infrastructure in Latin America

3 sem. hrs.

Students will explore the relationship between Latin American culture and engineering infrastructure. Emphasis is placed on alleviation of poverty and international development. Students will become familiar with 1) Latin American culture, history, and politics, 2) peace and justice issues, 3) water treatment, wastewater treatment, and environmental protection 4) engineering infrastructure, and 5) health care issues. The needs of developing countries and the advantages and disadvantages of highly developed infrastructure systems will be highlighted. Students are asked to reflect on the importance of engineering works in light of lecture and reading viewpoints, with the goal of gaining a richer understanding of the implications of culture

within infrastructure development. The course will culminate in each student writing a paper combining information gained through reading, lecture, and service learning to emphasize a course-related topic. Participation in an international or domestic service learning project is required. A variety of projects will be made available by the instructor.

CEEN 4931. Topics in Civil Engineering

1-3 sem. hrs.

Course content announced each term.

Prereq: Cons. of instr.

CEEN 4953. Environmental Seminar

0 sem. hrs.

Topics related to environmental engineering, including subjects such as air pollution, urban hydrology and stormwater management, wastewater treatment and hazardous waste management. Offered each term. SNC/UNC grade assessment.

CEEN 4991. Co-op Work Period 3

0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992, etc. Offered every term. Fee. SNC/UNC grade assessment.

CEEN 4992. Co-op Grading Period 3

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

CEEN 4993. Co-op Work Period 4

0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994 etc. Offered every term. Fee. SNC/UNC grade assessment.

CEEN 4994. Co-op Grading Period 4

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

CEEN 4995. Independent Study in Civil and Environmental Engineering

1-3 sem. hrs.

Undergraduate independent study project of either a theoretical or experimental nature. *Prereq: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.*

CEEN 4997. Civil Engineering Capstone Design

4 sem. hrs.

Design of selected civil engineering projects including planning, preliminary analysis and final design. Different projects are selected each year. Students are assigned to project teams with specific tasks under the direction of a faculty course coordinator. Professional engineers from local firms propose projects and act as consultants to each design team. Emphasis is placed on student initiative, responsibility and resourcefulness in an open-ended project. A final written design report and oral presentation are required for each design team. Emphasis on technical communications, professional ethics and engineering practices. Offered spring term. 3 hrs. lec., 3 hrs. lab. *Prereq: CEEN 3430 and CEEN 3440.*

Construction Engineering and Management (CEMA)

CEMA 3810. Introduction to Construction Management

3 sem. hrs.

Construction contracts, contract bonds, construction funding, cash flow analysis, labor productivity and cost. Analytical techniques for project planning and scheduling. Construction safety. Offered fall term. *Prereq: Jr. stndg, or cons. of instr.*

CEMA 3850. Construction Equipment and Methods

3 sem. hrs.

Construction equipment and productivity analysis. Design of equipment fleet operations. Building construction methods and design of temporary structures used during construction such as earth-retaining structures, formwork systems, and temporary bracing systems. Safety standards related to earthwork, concrete, masonry, carpentry and steel operations. Offered fall term. *Prereq: Sr. stndg.*

CEMA 3860. Construction Materials and Methods

3 sem. hrs.

Introduction to materials and methods of building construction and to construction drawings. Foundation, structural framing, floor, room and wall systems. Blueprint reading and quantity takeoff techniques. An introduction to building information modeling. *Prereq: CEMA 3810.*

CEMA 3991. Co-op Work Period 1

0 sem. hrs. Registration for approved cooperative program work assignments is required for all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992. Offered every term. SNC/UNC grade assessment.

CEMA 3992. Co-op Grading Period 1

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U Grade Assessment.

CEMA 3993. Co-op Work Period 2

0 sem. hrs. Registration for approved cooperative program work assignments is required for all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994. Offered every term. SNC/UNC grade assessment.

CEMA 3994. Co-op Grading Period 2

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U Grade Assessment.

CEMA 4815. Mechanical and Electrical Systems for Buildings

3 sem. hrs.

Provides basic knowledge of electrical, plumbing and HVAC systems used in residential, commercial and industrial buildings. Studies the advantages and disadvantages of various systems, and how their design and installation integrates into the management of the building process. Particular attention is given to soliciting and managing mechanical and electrical subcontractors. *Prereq: PHYS 1004.*

CEMA 4820. Construction Operations and Productivity

3 sem. hrs.

Study of construction operations with emphasis on productivity measurement and enhancement. Application of an integrated approach to planning, analysis and design of construction operations. Application of simulation models and other analytical tools for modeling construction operations. Study of productivity improvement strategies, including lean construction principles. *Prereq: Senior standing.*

CEMA 4825. E-Business in the Construction Industry

3 sem. hrs.

Explores the ways in which information technology and its Internet components help to provide competitive advantage for construction companies. Selection/implementation of Web-based project management tools. An investigation of digital technologies in construction industry. Wire/wireless communication, online plan/bid rooms, mobile computing, and video conferencing. *Prereq: Senior standing.*

CEMA 4830. Construction Planning, Scheduling, and Control

3 sem. hrs.

A study of principles and techniques used to plan, schedule and control costs on building construction projects. Network and linear scheduling models, resource allocation and time-cost analysis. Develops an appreciation of the resources required in a project and their limitations and introduces the techniques for analyzing and improving their use. Develops an understanding of the correlation between project planning and control and cost estimating and scheduling. *Prereq: CEMA 4825.*

CEMA 4840. Construction Cost Analysis and Estimating

3 sem. hrs.

Study of various cost estimating methods and their applications. Topics include: labor, material, equipment and indirect costs; quantity takeoff; analysis of historical cost data; forecasting and computerized estimating methods. Offered spring term. *Prereq: CEMA 3810 and CEMA 3850 or cons. of instr.*

CEMA 4931. Topics in Construction Engineering and Management

1-3 sem. hrs.

Course content announced each term.

Prereq: Cons. of instr.

CEMA 4991. Co-op Work Period 3

0 sem. hrs. Registration for approved cooperative program work assignments is required for all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992. Offered every term. SNC/UNC grade assessment.

CEMA 4992. Co-op Grading Period 3

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U Grade Assessment.

CEMA 4993. Co-op Work Period 4

0 sem. hrs. Registration for approved cooperative program work assignments is required for all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994. Offered every term. SNC/UNC grade assessment.

CEMA 4994. Co-op Grading Period 4

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U Grade Assessment.

ELECTRICAL AND COMPUTER ENGINEERING (EECE), (COEN) and (ELEN)

Chair and Professor: Yaz

Associate Chair, Associate Professor, Electrical Engineering Curriculum Coordinator: Schneider

Associate Professor and Computer Engineering Curriculum Coordinator: Riedel

Professor Emeritus and Director of Undergraduate Studies: Moeller

Adjunct Associate Professor and Director of Undergraduate Electrical Engineering Laboratories: Jacoby

Associate Professor and Director of Undergraduate Computer Engineering Laboratories: Povinelli

Professor and Director of Graduate Studies: Josse

Professor Emeriti: Heinen, Hock, Ishii, Seitz

Professor: Corliss, Demerdash, Heinrich, Jaskolski, Joshi, Jeutter, Matthys

Associate Professor: Brown, Feng, Johnson, Richie

Adjunct Associate Professor: Davis, Schmidt

Adjunct Assistant Professor: Deibele, Kelnhofer

Adjunct Professor: Datkos, Pistré

Research Professor: Arkadan

Research Associate Professor: Hirthe

Research Assistant Professor: Koehler

Electrical and Computer Engineering (EECE)

Curriculum Coordinator: Schneider

EECE 1610. Introduction to Computer Programming 3 sem. hrs.

Students will be introduced to computer programming with an emphasis on object-oriented programming (OOP) and OOP design methodologies. The students will learn about typical programming constructs including data types, data structures, control structures, data input and output techniques as well as several algorithms used for solving engineering problems. In addition, students will learn to use modern programming tools in an integrated development environment by focusing on developing software solutions to significant engineering problems.

EECE 1953. Freshman Seminar 1 1 sem. hr.

Introduction to electrical engineering and computer engineering through presentations by faculty, graduate students, upper-class undergraduate students, alumni, and industry representatives. A formal opportunity for first-year COEN, ELCE, and ELEE students to interact with their peers and other members of the EECE Department. Offered fall term.

EECE 1954. Freshman Seminar 2 1 sem. hr.

Continuation of EECE 1953. COEN, ELCE, and ELEE students will have further opportunities to investigate electrical engineering and computer engineering applications through presentations by faculty, graduate students, upper-class undergraduate students, alumni, and industry representatives. Offered spring term.

EECE 2010. Electric Circuits 1 3 sem. hrs.

Ohm's law and Kirchhoff's laws. Mesh and loop analysis of resistive circuits with DC sources. Source transformations. Thevenin's and Norton's theorems. Natural and step response of first- and second-order circuits. Circuits with ideal op amps. Offered fall term. *Prereq: MATH 1451 or MATH 1455, which may be taken concurrently.*

EECE 2015. Circuits Laboratory 1 1 sem. hr.

Introduction to circuit design, construction, and test. The basics of circuit construction techniques and electronic test measurement skills are covered. Circuit components such as resistors, inductors, capacitors and op-amps are used. Emphasis placed on DC and transient response of circuits. 1 hr. lec., 2 hrs. lab. EECE 2010 must be taken concurrently.

EECE 2030. Digital Electronics 4 sem. hrs.

Introduces students to the basic principles of digital circuit analysis and design. Topics covered include: Boolean Algebra, number systems, basic logic gates, standard combinational circuits, combinational design, timing diagrams, flip-flops, sequential design, standard sequential circuits and programmable logic devices. Offered fall term. *Prereq: Jr. stndg.*

EECE 2035. Circuits Laboratory 2 1 sem. hr.

Circuit design, construction, and test skills are expanded to include diode circuits and transistor amplifiers as well as passive and active filters. Emphasis placed on DC, AC and transient response of circuits containing passive and active devices. 1 hr. lec., 2 hrs. lab.

Prereq: EECE 3010, which may be taken concurrently, EECE 2010 with minimum grade of C, ELEN 2020, which may be taken concurrently, and EECE 2015 with minimum grade of C.

EECE 2710. Introduction to Computer Hardware and Software 3 sem. hrs.

Overview of computer hardware: information representation, the control unit, implementation of instruction sets, memories and storage devices, internal bus organization, the arithmetic/logic unit, the input/output unit, interfacing peripherals. Overview of computer software, operating system components: memory management, input/output, file management, scheduling, resource management. Layered operating system design, programming languages and language translators, application layer design, software tools, and system design and design process. Programming exercises in machine and assembly language and in the JAVA programming language. Offered fall term.

Prereq: EECE 1610 or COSC 1010.

EECE 3010. Electronic Devices and Applications 3 sem. hrs.

Electronic components are discussed including semiconducting diodes, bipolar junction transistors, field effect transistors, etc. These devices will be analyzed from their terminal characteristics and their behavior in representative electronic circuits. Applications for devices include simple power supply analysis and design, class A amplifier analysis including transistor biasing and stability analysis, simple digital logic gates, etc. Offered spring term. *Prereq: EECE 2010 with minimum grade of C.*

EECE 3015. Digital Electronics Laboratory 2 sem. hrs.

Gaining experience in the design, assembly, testing, and trouble-shooting of digital electronic circuits. Experiments encompass a wide range of topics such as: basic logic gates, integrated circuit specifications, Boolean algebra implementations, standard combinational circuits, sequential circuit design, standard sequential circuits, programmable logic devices, digital interfacing, and microprocessors. 7400 series ICs, PALs, PROMs, and microprocessor devices are used. Offered both terms. 1 hr. lec., 3 hrs. lab. *Prereq: ELEN 2030 with a minimum grade of C and EECE 2710, which may be taken concurrently; or ELEN 2020 with a minimum grade of C and BIEN 3200, which may be taken concurrently.*

EECE 4410. Integrated Microelectronic Circuits 3 sem. hrs.

Basic processing technology of integrated circuits, passive components and their parasitic effects, MOS transistors, bipolar transistors and diodes, design of silicon integrated circuits. Emphasis is placed on the design of circuits to meet given requirements. Design Elective. *Prereq: EECE 3010 and ELEN 2020.*

EECE 4510. Digital Signal Processing 3 sem. hrs.

Mathematical descriptions of discrete-time signals and systems are presented using block diagrams, signal flow graphs, and difference equations. The sampling and reconstruction of continuous-time signals is presented. Frequency analysis techniques are covered, including the z-transform, the Discrete Fourier Transform, and the Fast Fourier Transform. Simple digital filter design examples are presented. DESIGN ELECTIVE. *Prereq: ELEN 3020 or COEN 2020.*

Computer Engineering (COEN)

Curriculum Coordinator: Riedel

COEN 2020. Electric Circuits 2 3 sem. hrs.

Sinusoidal steady-state analysis. Power in AC circuits. Linear and ideal transformers. Laplace transform methods and circuit analysis applications. Passive and active frequency-selective circuits. Fourier methods. Overview of discrete-time analysis. Offered spring term.

Prereq: EECE 2010 with minimum grade of C.

COEN 2610. Software Methodologies 3 sem. hrs.

The first course in software engineering, covering the software life cycle, proper selection of data structures and algorithms, and the availability and choice of programming paradigms for appropriate design and implementation of well-engineered software. An open laboratory and significant programming experiences form an integral part of this course. Offered spring term.

Prereq: EECE 1610 or COSC 1010.

COEN 3991. Co-Op Work Period 1 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. SNC/UNC grade assessment.

COEN 3992. Co-Op Grading Period 1

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.

COEN 3993. Co-Op Work Period 2

0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994, etc. Fee. SNC/UNC grade assessment.

COEN 3994. Co-Op Grading Period 2

1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.

COEN 4610. Object-Oriented Software Engineering

3 sem. hrs.

Presents advanced software engineering concepts in the context of object-oriented analysis and design. Topics include: issues and applications, requirements engineering, software specifications, modeling notations, software quality, testing and correctness, software reuse, and reverse engineering. COEN design elective in the area of software. *Prereq: COEN 2610 or COSC 1020.*

COEN 4620. Modern Programming Practices

3 sem. hrs.

Explores advanced topics in computer programming. Topics may include: design patterns, advanced graphical components, software component models such as Java Beans, the Java Security model, Java and databases, servlets, Java Server Pages, and Enterprise Java Beans. COEN design elective in the areas of applications and software. *Prereq: COSC 2100 or COSC 2010.*

COEN 4630. Software Testing

3 sem. hrs.

Examines the relationship of software testing to quality, emphasizing testing techniques and the role of testing in the validation of system requirements. Topics include: module and unit testing, integration, walkthroughs and inspections, verification and validation, preventing and detecting errors, selecting and implementing project metrics, and defining test plans and strategies traced from system requirements. COEN design elective in the areas of applications and software. *Prereq: EECE 2710, COSC 2100, COSC 2010, or equivalent experience.*

COEN 4650. Introduction to Algorithms

3 sem. hrs.

Introduction to the algorithms analysis. Topics to be covered include: the concepts of time and space complexity, advanced data structures, general issues in problem solving methodologies, greedy algorithms, dynamic programming, graph algorithms, AI-related algorithms, and an introduction to NP-completeness theory. COEN design elective in the area of intelligent systems.

Prereq: EECE 2710 or COSC 2200 or equiv.

COEN 4690. Developments in Computer Software

3 sem. hrs.

Course content is announced prior to each semester. Students may enroll in the course more than once because subject matter changes. COEN design elective. *Prereq: Cons. of instr.*

COEN 4710. Computer Hardware

3 sem. hrs.

Overview of computer system design. Cost and performance specification. Design of arithmetic and logic units. Fundamentals of central processor architecture and a comparative study of computer instruction set architectures. Detailed study of microprocessors, including instruction execution timing and other timing considerations. Discussions of memory and I/O devices, including the interfaces to the CPU and I/O transfer techniques. Study of common bus standards. Design elective for Electrical and Electronics major. Offered spring term. *Prereq: EECE 2710 with minimum grade of C and EECE 2030 with minimum grade of C; or COSC 2200 with minimum grade of C and EECE 2030 with minimum grade of C.*

COEN 4720. Embedded Systems Design

3 sem. hrs.

This course introduces students to embedded systems, the types of hardware that can support such systems, and the interfacing used in embedded systems. The course is a combined laboratory and lecture course, which directly applies the embedded systems techniques using hardware description and assembly languages to field programmable gate array technology. Design elective for Electrical and Computer Engineering majors. *Prereq: COEN 4710 and EECE 3015.*

COEN 4730. Computer Architecture

3 sem. hrs.

Review of basic computer architecture. Evaluation of architecture performance. Design and evaluation of instruction sets. Pipeline processors and instruction scheduling. Vector processors. Memory hierarchy and design including cache, main and virtual memories. Memory protection schemes. Input/output and its relation to system performance. COEN design elective in the area of hardware. *Prereq: Sr. stndg., 3.000 GPA, and COEN 4710; or cons. of instr.*

COEN 4790. Developments in Computer Hardware

3 sem. hrs.

Course content is announced prior to each semester. Students may enroll in the course more than once because subject matter changes. COEN design elective. *Prereq: Cons. of instr.*

COEN 4810. Database Applications

3 sem. hrs.

Presents the design and application of databases. Topics include: models for databases, database query languages, database design methods, methods for storing and retrieving information from a database, database optimizations, transaction processing, and a brief examination of some advanced concepts, including object databases, distributed databases and database security. COEN design elective in the area of applications. *Prereq: COSC 2100 or COSC 2010 or equiv.*

COEN 4820. Operating Systems and Networking

3 sem. hrs.

Introduces the fundamental concepts of operating systems together with the basics of networking and communications including: memory management, scheduling, concurrent processing, device management, file systems, networking, security, and system performance. Examples are drawn from legacy

and modern operating systems. Design elective for Electrical and Computer Engineering majors. *Prereq: COSC 2100 or COSC 2010.*

COEN 4830. Introduction to Computer Graphics

3 sem. hrs.

Introduction to computer graphics algorithm design and implementation; includes considerable actual computer graphics experience. Topics include: point-plotting and line-drawing techniques, two-dimensional curve fitting, two-and three-dimensional graphics, clipping, windowing, hidden line removal, modeling, input-output devices, and other topics as future trends dictate. COEN design elective in the area of applications. *Prereq: Proficiency in at least one high level computing language.*

COEN 4840. Computer Security

3 sem. hrs.

Introduction to the important issues in computer security, including cryptography, program security, operating system security, database security, and network security. Also discusses the legal, ethical and privacy issues that arise in computer security. Programming projects enable the student to practice implementing many of the security measures discussed in class. COEN design elective in the areas of software, intelligent systems and applications. *Prereq: COSC 2100 or COSC 2010 or equiv.*

COEN 4850. Introduction to Intelligent Systems

3 sem. hrs.

Provides a broad exposure to intelligent systems, including related fields such as artificial and computational intelligence. Topics include: intelligent agents, search, game playing, propositional logic and first-order predicate calculus, uncertainty, learning, communication and perception, and philosophical foundations of intelligent systems. COEN design elective in the area of intelligent systems. *Prereq: COSC 2100 or COSC 2010; MATH 1450; MATH 2100 or MATH 2105.*

COEN 4860. Introduction to Neural Networks and Fuzzy Systems

3 sem. hrs.

Concepts of neural network architectures training algorithms, supervised and unsupervised learning, linear and non-linear neural networks, feedback neural networks, applications in scientific and engineering areas, fundamentals of fuzzy sets, and fuzzy logic, fuzzy rules and inference systems, fuzzy pattern classification and clustering analysis, and fuzzy control systems. COEN design elective in the area of intelligent systems. *Prereq: COSC 2100 or COSC 2010 and MATH 1451.*

COEN 4870. Evolutionary Computation

3 sem. hrs.

Evolutionary computation consists of a set of search methods based on the Darwinian principle of survival of the fittest. The methods include genetic algorithms, evolutionary strategies, and evolutionary and genetic programming. These methods have been successfully applied to many different problem domains including optimization, learning, control, and scheduling. Provides students with the background and knowledge to implement various evolutionary computation algorithms, discusses trade-offs between different evolutionary algorithms and other search methods, and discusses issues related to the application and performance evaluation of evolutionary algorithms. COEN design elective in the area of intelligent systems. *Prereq: COSC 2100 or COSC 2010 and MATH 1450; and MATH 2100 or MATH 2105.*

COEN 4890. Developments in Computer Applications 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include advanced hardware (MPP, EPIC, VLIW), advanced software (enterprise systems, embedded software, real-time software) and advanced intelligent systems.
Prereq: Cons. of instr. or Sr. stdng.

COEN 4920. Principles of Design 3 sem. hrs. Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). Offered Fall semester. 2 hrs. lec., 2 hrs. lab.
Prereq: Sr. stdng.; Co-op students, Jr. stdng. Cross-listed with BIEN 4920, ELEN 4920 and MEEN 4920.

COEN 4991. Co-Op Work Period 3 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992, etc. Fee. SNC/UNC grade assessment.

COEN 4992. Co-Op Grading Period 3 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.

COEN 4993. Co-Op Work Period 4 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994, etc. Fee. SNC/UNC grade assessment.

COEN 4994. Co-Op Grading Period 4 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.

COEN 4995. Independent Study in Computer Engineering 1-4 sem. hrs.

Undergraduate independent study project of either a theoretical or experimental nature.
Prereq: Jr. stdng., 3.000 GPA, cons. of instr., and cons. of dept. ch.; or Sr. stdng., 3.000 GPA, cons. of instr., and cons. of dept. ch.

COEN 4998. Senior Design Project 3 sem. hrs. Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team

design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. Offered Spring semester. 2 hrs. lec., 2 hrs. lab.
Prereq: COEN 4920; Cross-listed with BIEN 4998, ELEN 4998 and MEEN 4998.

Electrical Engineering (ELEN)

Curriculum Coordinator: Schneider

ELEN 2020. Electric Circuits 2 3 sem. hrs. Sinusoidal steady-state analysis. Power in AC circuits. Linear and ideal transformers. Laplace transform methods and circuit analysis applications. Passive and active frequency-selective circuits. Balanced three-phase circuits. Two-port circuits. Offered spring term.
Prereq: EECE 2010 with minimum grade of C.

ELEN 3001. Electric Circuits and Machinery 3 sem. hrs. Circuit modeling; basic solution methods for d-c and a-c circuits; d-c and a-c machines.
Prereq: PHYS 1004 or PHYS 1014. May not be taken for credit by EECE students.

ELEN 3002. Electric Circuits and Electronics 4 sem. hrs. An experience in electrical circuits (AC and DC), electronic devices (junction, transistor, operational amplifier), bridges, digital circuits and Boolean implementation, combinational and sequential logic, memories. Use of PSpice software and Laplace transform. Analysis and design. This course may not be taken for credit by students in the Electrical Engineering programs.
Prereq: PHYS 1004 or PHYS 1014.

ELEN 3020. Linear Systems Analysis 4 sem. hrs.

Mathematical models of continuous-time and discrete-time signals and systems are studied in this course. The time domain viewpoint is developed for linear time invariant systems using the impulse response and convolution integral. The frequency domain viewpoint is also explored through the Fourier Series and Fourier Transform. Basic filtering concepts including simple design problems are covered. Application of the Laplace transform to block diagrams, linear feedback, and stability including Bode plots are discussed. The sampling theorem, the z-transform, and the Discrete Fourier Transform are introduced. Examples of electrical, mechanical, and biomedical signals and systems are used extensively throughout the course. Offered fall term.
Prereq: ELEN 2020 with minimum grade of C and MATH 2451; or ELEN 3002 with minimum grade of C and MATH 2451; or BIEN 2300 with minimum grade of C and MATH 2451; or ELEN 3001 with minimum grade of C and MATH 2451.

ELEN 3025. Electrical Instrumentation Laboratory 2 sem. hrs.

Develops familiarity with typical electronic instruments and terminology. Combines theory with experience to analyze and design electrical networks. Learning experimental technique and documentation. Offered fall term. 1 hr. lec., 3 hrs. lab.
Prereq: EECE 3010 with minimum grade of C, ELEN 2020 with minimum grade of C, and EECE 2015 with minimum grade of C.

ELEN 3030. Analog Electronics 4 sem. hrs. Analysis and design of analog electronic circuits. Low and high frequency models for both bipolar and field effect transistors. Design features and operating characteristics of integrated linear circuits with emphasis on operational amplifiers and op-amp circuits. Offered spring term.
Prereq: EECE 3010 with minimum grade of C and ELEN 2020 with minimum grade of C.

ELEN 3035. Analog Electronics Laboratory 2 sem. hrs.

Gaining experience in the design, assembly, testing, and trouble-shooting of analog electronic circuits. Experiments encompass a wide range of topics such as: amplifiers, filters, power supplies, power control, oscillators, and communication circuits. Transistors, op-amps, general purpose, and specific purpose devices are used. Offered fall term. 1 hr. lec., 3 hrs. lab. *Prereq: ELEN 3030 with minimum grade of C and ELEN 3025 with minimum grade of C.*

ELEN 3110. Electromagnetic Fields 1 4 sem. hrs.

Development and use of the point and integral forms of Maxwell's equations for static and quasi-static electric and magnetic fields with emphasis placed on the vector nature of these fields. Includes analytic and computational solutions to field's problems. The wave equation for E.M. fields is derived and discussed. Offered fall term.
Prereq: ELEN 2020 with minimum grade of C, MATH 2450, PHYS 1004 or PHYS 1014 and knowledge of a higher level computer language.

ELEN 3120. Electromagnetic Fields 2 3 sem. hrs.

Development and use of Wave Equations as derived from Maxwell's equations to explain the propagation of electromagnetic waves. Includes treatment of physical optics, antennas, wave-guides and transmission lines. Offered spring term.
Prereq: ELEN 3110 with minimum grade of C.

ELEN 3210. Electric Drives 3 sem. hrs. Application of electromagnetic field and circuit theory to electromechanical energy conversion systems. Solutions for the magnetic fields, electromagnetic and electrostatic induced forces, and equivalent circuits using conservation of energy principles. Operation of electric machinery from solid-state power switch converters. Offered spring term.
Prereq: ELEN 3110 with minimum grade of C.

ELEN 3991. Co-op Work Period 1 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. SNC/UNC grade assessment.

ELEN 3992. Co-op Grading Period 1 1 sem. hr. Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. No tuition is charged for Grading Periods. S/U grade assessment.

ELEN 3993. Co-op Work Period 2 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994, etc. Fee. SNC/UNC grade assessment.

ELEN 3994. Co-op Grading Period 2 1 sem. hr. Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. No tuition is charged for Grading Periods. S/U grade assessment.

ELEN 4015. Advanced Electrical Engineering Laboratory 3 sem. hrs.

Project-based laboratory experience in the design, assembly and testing of advanced electronic and electrical systems. Course content announced prior to each term. Students may enroll in the course more than once as the content of the course changes. Possible topics for the advanced laboratory experience include (but are not limited to) advanced electromagnetic system design, optical and high frequency electronics, nonlinear control systems, motor control circuits and systems, power electronics, communications circuits, integrated microelectronic circuit design and fabrication (VLSI), advanced analog system design, advanced digital system design, microprocessor system-level design. Instruction and use of the appropriate test and measurement tools for design, assembly and testing of systems. Offered spring term. 2 hrs. lec., 2 hrs. lab. *Prereq: Cons. of instr.*

ELEN 4090. Developments in Electronics 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include laser electronics, optoelectronics and photonics, RF circuit design, SOC design. *Prereq: Cons. of instr. or Sr. stndg.*

ELEN 4130. Antenna Theory and Design 3 sem. hrs.

Design and use of antennas of varying types, including wire, broadbands, horn, and reflector antennas in transmitting and receiving applications. The application and design of antenna arrays, and an introduction to diffraction theory. DESIGN ELECTIVE. *Prereq: ELEN 3120.*

ELEN 4150. Applied Finite Elements in Electromagnetics 3 sem. hrs.

Introduction to finite element (FE) analysis as applied to linear and static electromagnetic field problems. Review of basic field formulations using Maxwell's electromagnetic field equations, solution of boundary value problems using the finite difference methods, FE formulations, assembly of elemental and global matrices, pre-processing, post-processing. Application of the FE method using one-dimensional and two-dimensional elements, magnetostatic and electrostatic analysis, and the use of commercially available software packages. *Prereq: ELEN 3110 or equiv.*

ELEN 4190. Developments in Electromagnetics 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include wireless and microwave components and systems, electromagnetic compatibility, radio wave propagation. *Prereq: for ELEN 4190: Cons. of instr. or Sr. stndg.*

ELEN 4210. Design and Analysis of Electric Motor-Drive Systems 3 sem. hrs.

Principles of design of AC and DC electric machines, in particular design of electric motors in power electronically controlled adjustable speed drives, torque and power to volume analysis under constant volts per hertz torque-speed control. Design of AC induction, synchronous, universal and DC conventional as well as brushless DC motors, and low horsepower motors in adjustable speed drives is covered. Effects of space and time harmonics on motor design and performance are covered including harmonic abatement for control of torque pulsation. Modern modeling techniques are studied and used throughout. Design elective. *Prereq: ELEN 2020 or equiv., ELEN 3110 or equiv., and ELEN 3210 or equiv.*

ELEN 4220. Power Electronics for Renewable Energy Systems 3 sem. hrs.

Fundamental concepts, techniques, and methods for design and analysis of power electronic systems. Modeling of semiconductor switching devices for use in power electronic systems. Practical aspects and power electronic conversion techniques for rectifiers, DC-to-DC converters, DC-to-AC inverters and their applications in power electronic systems. DESIGN ELECTIVE for EECE Program. *Prereq: ELEN 3030 and ELEN 3020.*

ELEN 4230. Electric Energy Systems Analysis 3 sem. hrs.

Elements of electric power systems; fundamental concepts and techniques for design and analysis; per unit system; load flow; economic dispatch; symmetrical components; balanced and unbalanced fault calculations, system instrumentation and power system protection. Design Elective. *Prereq: ELEN 2020 and ELEN 3020.*

ELEN 4240. Protection and Monitoring of Electric Energy Systems 3 sem. hrs.

Principles of design of relay and sensor systems for detection of faulty operating conditions in electric generators, transformers, power transmission lines, motors and other loads in power systems. Balanced and unbalanced faults include single and multiple unbalances. Design and hierarchical coordination of protection systems for interconnected generation, transmission and distribution facilities in power systems. This includes integrated generator-transformer-busbar-transmission line-load protection and analysis of operation under fault conditions. Design elective. *Prereq: ELEN 2020 or equiv., ELEN 3110 or equiv., and ELEN 3210 or equiv.*

ELEN 4250. Transients in Electric Energy Systems and Devices 3 sem. hrs.

The study of microsecond fast transients in power systems and devices resulting from lightning strokes, switching surges in power systems and devices, as well as impulse surges resulting from pulse width modulation in modern adjustable speed drives, using distributed parameter models and analysis of transmission lines and windings of transformers, generators and motors. Successive reflections, transition points, wavefront flattening techniques and surge arrester design applications for voltage buildup reduction and control are studied. Polyphase multi-velocity multi-conductor system transients are included. Design elective. *Prereq: ELEN 2020 or equiv. and ELEN 3110 or equiv.*

ELEN 4290. Developments in Energy and Power 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include electronics for machine and drive systems, electrical transients, faults and diagnostics and protection in power devices and systems, renewable energy systems and advanced topics in the electric power engineering area. *Prereq: cons. of instr. or Senior Standing.*

ELEN 4310. Control Systems 3 sem. hrs.

Review of continuous-time linear systems. Time-domain system analysis. Time-domain design of lead/lag and PID controllers. Root-Locus technique. Frequency-domain system analysis including Nyquist, Bode, and Nichols analysis and relative stability. Frequency-domain design/lag and PID controllers. DESIGN ELECTIVE. *Prereq: ELEN 3020.*

ELEN 4320. Digital Control Systems 3 sem. hrs.

Review of sampling processes, discrete time linear systems analysis and z-transform. Discrete time and sampled data state-variable analysis. Stability analysis, time domain and frequency-domain analysis and design. Analysis, design and computer implementation of digital algorithms and control systems. Design Elective. *Prereq: ELEN 3020 with minimum grade of C.*

ELEN 4390. Developments in Control 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include optimal, adaptive and robust control methods, digital control and nonlinear systems. *Prereq: Cons. of instr. or Senior Standing.*

ELEN 4430. Physical Principles of Solid State Devices 3 sem. hrs.

Fundamental physical principles of solid state devices are presented. The operation of modern semiconductor devices is explained from first principles and these principles are used to extend the students' knowledge of devices used in electronic circuits. Offered fall term. *Prereq: EECE 3010 with minimum grade of C, ELEN 3110 with minimum grade of C, and PHYS 1004 or PHYS 1014.*

ELEN 4450. Surface Acoustic Wave Devices 3 sem. hrs.

This course is concerned with the theory and applications of surface acoustic wave devices. Major topics covered include: theory of surface and other acoustic wave modes; design, analysis, and performance of interdigital devices; SAW bandpass filters; oscillators and sensors; and applications of SAW devices in wireless communications. Design Elective. *Prereq: ELEN 3020 and ELEN 3110; or cons. of instr.*

ELEN 4460. Sensor Devices: Theory, Design, and Applications 3 sem. hrs.

Sensor classification and transduction principles. Fundamental principles and theory of operation of various types of sensors, based on various technologies which include optical, electrical, acoustical, thermal, magnetic, mechanical and chemical. Analysis of sensor signals. Study of sensor characteristics which include hysteresis, non-linearity, saturation, repeatability, sensitivity, selectivity and resolution. Design and practical implementations of various sensors for scientific, industrial and consumer applications. Design elective.
Prereq: Sr. stndg.

ELEN 4490. Developments in Devices 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include optoelectronic devices, nano-scale devices, solid-state devices, integrated electronic devices, power devices, electro-mechanical devices, quantum devices.
Prereq: Cons. of instr. or Sr. stndg.

ELEN 4550. Developments in Signal Processing 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include filter design, DSP hardware, Nonlinear signal processing and multi-dimensional signal processing.
Prereq: Cons. of instr. or Sr. stndg.

ELEN 4560. Introduction to Communication Systems 3 sem. hrs.

Orthogonality and signal representation. The Fourier transform and applications, power spectral density, amplitude modulation, angle modulation, pulse modulation, frequency modulation and digital transmission. *Prereq: ELEN 3020.*

ELEN 4565. Optical Fiber Communications 3 sem. hrs.

Fundamental principles and theories of optical fiber systems are introduced and developed. Review of electromagnetic principles of wave-guides. Step-Index and Graded-Index, single and multimode fibers. Signal analysis in optical fibers: mode interaction, attenuation, dispersion and pulse spreading. Operating characteristics of optical sources and photo-receivers with impact on system performance. Coupling to a fiber and distribution system. Optical fiber communication system design. Design Elective.
Prereq: Sr. stndg. and ELEN 3110.

ELEN 4570. Wireless Communications 3 sem. hrs.

Fundamentals, analysis and design of cell systems, including trunking theory and grade of service. Large scale and small scale path loss analysis and modeling. Overview of modulation techniques, including amplitude and frequency modulating, and digital modulation techniques. Design Elective.
Prereq: ELEN 3020 and ELEN 3110.

ELEN 4590. Developments in Communications 1-3 sem. hrs.

Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature. Possible topics include digital modulation and detection, coding theory, information theory.
Prereq: Cons. of instr. or Sr. stndg.

ELEN 4920. Principles of Design 3 sem. hrs.

Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this two-course sequence. Offered Fall semester. 2 hrs. lec., 2 hrs. lab.
Prereq: Sr. stndg.; Co-op students, jr. stndg. Cross-listed with BIEN 4920, COEN 4920 and MEEN 4920.

ELEN 4991. Co-op Work Period 3 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992, etc. Fee. SNC/UNC grade assessment.

ELEN 4992. Co-op Grading Period 3 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. No tuition is charged for Grading Periods. S/U grade assessment.

ELEN 4993. Co-op Work Period 4 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994, etc. Fee. SNC/UNC grade assessment.

ELEN 4994. Co-op Grading Period 4 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. No tuition is charged for Grading Periods. S/U grade assessment.

ELEN 4995. Independent Study in Electrical Engineering 1-4 sem. hrs.

Undergraduate independent study project of either a theoretical or experimental nature.
Prereq: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.

ELEN 4998. Senior Design Project 3 sem. hrs.

Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. Offered Spring semester. 2 hrs. lec., 2 hrs. lab.
Prereq: ELEN 4920. Cross-listed with BIEN 4998, COEN 4998 and MEEN 4998.

MECHANICAL ENGINEERING (MEEN)

*Chairperson and Professor: Kim
Associate Chairperson and Director of Undergraduate Studies: Fournelle
Director of Graduate Studies: Rice
Professor: Fournelle, Harris, Heinrich, Marklin, Schimmels, Stango, Widera
Professor Emeriti: Blumenthal, Brebrick, Brower, Gaggioli, Nigro, Seitz
Adjunct Professor: Stilp
Associate Professor: Borg, Cariapa, Domblesky, Jensen, Nagurka, Rice, Silver-Thorn, Weber
Research Associate Professor: Park
Adjunct Associate Professor: Shana, Toth
Assistant Professor: Goldsborough, Koch, Voglewede
Research Assistant Professor: Bowman, Huang*

MEEN 2110. Statics 3 sem. hrs.

Fundamentals of forces and force systems. Internal and external forces. Support reactions. Definition of a free-body diagram (FBD). Emphasis on development of FBD-drawing skills. Moment of a force. Force system resultants. Vector methods in two and three dimensions. Equilibrium analysis of particles and rigid bodies. Truss analysis by methods of joints and sections. Analysis of simple frames and machines. Analysis of friction. Centroids of composite areas and volumes. Resultants of distributed loads. Offered each term.
Prereq: MATH 1451 or MATH 2566, which may be taken concurrently. Same as CEEN 2110.

MEEN 2120. Dynamics 3 sem. hrs.

Fundamentals of motion of particles and rigid bodies. Application of Newton's laws. Principles of position, velocity, and acceleration. Use of work-energy and impulse-momentum methods. Introduction to vibrations. Offered each term. *Prereq: CEEN 2110 or MEEN 2110. Same as CEEN 2120.*

MEEN 2122. Statics and Dynamics 4 sem. hrs.

Fundamentals of forces, force systems and their application to static and dynamic bodies and systems of particles emphasizing vector methods in two and three dimensions. Equations of equilibrium. Friction, applications of Newton's laws, energy and momentum methods. Offered each term.
Prereq: MATH 1451 or MATH 1455, which may be taken concurrently. Same as CEEN 2122.

MEEN 2130. Mechanics of Materials 3 sem. hrs.

Concepts of stress, strain and deflection. Factor of safety. Mechanical properties of materials. Stress and deformation calculations for cases of axially loaded rods, torsion of circular shafts, beam bending and combined loading. Horizontal shear connectors in built-up beams. Area moment of inertia. Parallel-axis theorem. Introduction to beam design. Stress

concentration. Stress transformation and principal stress calculation by Mohr's circle. Statically indeterminate analysis. Elastic buckling of columns. Offered each term. *Prereq: CEEN 2110 or MEEN 2110. Same as CEEN 2130.*

MEEN 2210. Electromechanical Engineering Systems 3 sem. hrs.

Electromechanical engineering systems and the Engineering System Investigation Process. Physical and mathematical modeling of mechanical, electrical, magnetic, and electromechanical systems. Dynamic analysis: time response and frequency response; analytical and numerical simulation. Electromechanical actuators: solenoid, vibration exciter, and brushed DC motor. Introduction to measurement systems: analog and digital; motion, electrical, and magnetic sensors. Electronics for actuators, sensors, and controls. Introduction to control systems: analog vs. digital, open-loop vs. closed loop, stability and performance. Introduction to On-Off and PID control. Industrial case studies emphasizing integration. Laboratory exercises throughout the course. Extensive use of MatLab and LabView software programs. Offered spring term. 2 hrs. lec., 2 hrs. lab. *Prereq: PHYS 1004, MATH 2451 (which may be taken concurrently), MEEN 2120 (which may be taken concurrently).*

MEEN 2402. Engineering Economy 2 sem. hrs. Economic analysis for engineering and managerial decisions in the firm, value analysis, equipment replacement, evaluation of competing projects, inflation, cash flows, tax problems, depreciation, time value of money and various techniques of analyzing and reducing costs. Offered spring term.

MEEN 2460. Materials Science 3 sem. hrs. Atomic structure of matter, types of bonding, crystallography, role of imperfections, and ionic diffusion. Electric, magnetic, dielectric, and semiconducting properties. Mechanical properties, corrosion, and phase diagrams. Offered every term. *Prereq: CHEM 1001, which may be taken concurrently.*

MEEN 3210. Multidisciplinary Engineering Systems 3 sem. hrs.

Multidisciplinary engineering systems and the engineering system investigation process. Physical and mathematical modeling of thermal, fluid, and multidisciplinary systems. Dynamic analysis: time response and frequency response; analytical and numerical simulation. Electromechanical actuators; brushless DC motors and step motors. Fluid actuators: hydraulic and pneumatic. Measurement systems: analog and digital; thermal and fluid sensors. Electronics for actuators, sensors, and controls. Control system design: root-locus and frequency-response methods, PID control, state-space control, industrial control. Industrial case studies emphasizing integration. Laboratory exercises throughout the course. Extensive use of MatLab and LabVIEW. Offered spring term, 2 hrs. lec., 2 hrs. lab. *Prereq: MEEN 2210.*

MEEN 3220. Dynamics of Mechanical Systems 3 sem. hrs.

Analytical and computational analysis of the kinematics and kinetics of planar multi-body mechanical systems. Vibration analysis of single degree of freedom systems. Engineering applications including dynamic balancing, vibration absorption and vibration isolation. Offered fall term. *Prereq: MATH 2451 or MATH 2445; and CEEN 2120 or MEEN 2120.*

MEEN 3250. Design of Machine Elements 1 4 sem. hrs.

Detailed design of structural elements, shafts, gears, bearings, and other machine elements. Laboratory activities which cover the theoretical and experimental analysis of machine elements. Offered spring term. 3 hrs. lec., 2 hrs. lab. *Prereq: CEEN 2110 or MEEN 2110; and CEEN 2130 or MEEN 2130.*

MEEN 3260. Numerical Methods of Mechanical Systems 3 sem. hrs.

Numerical algorithms (math analysis, optimization, function approximation) for analysis and preliminary design of engineering systems. Development and use of MATLAB functions. Finite element software for solid modeling and analysis of elastic systems. Offered fall term. 3 hrs. lec., 1 hr. lab. *Prereq: MEEN 3220 and CEEN 2130 or MEEN 2130.*

MEEN 3270. Measurements and Instrumentation 3 sem. hrs.

Instrumentation systems including transducers, signal conditioners and readout devices. Oscilloscopes, recorders, bridges. Measurement of force, displacement, flow, temperature, pressure and other engineering parameters. Offered spring term. 2 hrs. lec., 2 hrs. lab. *Prereq: MATH 1451 and PHYS 1004 or PHYS 1014; or ELEN 3001 and MATH 1451.*

MEEN 3310. Thermodynamics 1 3 sem. hrs.

Elementary principles of equilibrium thermodynamics of pure and mixed substances, including applications to systems and processes. Relationships between heat and work, the first law of thermodynamics, are applied to either open or closed systems, operating at either steady or unsteady conditions. Second law of thermodynamics is applied to assessing the efficiency of devices and systems. Offered every term. *Prereq: MATH 1451 or MATH 1455; PHYS 1003 or PHYS 1013*

MEEN 3320. Fluid Mechanics 3 sem. hrs.

Fundamental conservation laws of mass, momentum and energy as applied to fluid systems. Properties of fluids, hydrostatics, flow of real fluids in closed and open systems, dynamic similarity, dimensional analysis and viscous and inviscid fluid flow. Offered every term. Same as CEEN 3150. *Prereq: MATH 2450 and MEEN 2120 or CEEN 2120 or MEEN 2122 or CEEN 2122.*

MEEN 3330. Fundamentals of Heat Transfer 3 sem. hrs.

Overview of principal mechanisms of heat transfer: conduction, convection, and thermal radiation. Application of conduction and forced convection to heat exchangers. Discussion of theory and applications of conduction, forced and natural convection, boiling and condensation and thermal radiation. Offered spring term. *Prereq: MATH 2451, MEEN 3310, and MEEN 3320.*

MEEN 3340. Thermodynamics 2 3 sem. hrs.

This course is the culmination of thermodynamic, fluid and heat transfer concepts to the application of power and refrigeration cycles, psychrometrics systems, and combustion processes. Course includes a laboratory section in which experiments are conducted to demonstrate, test, and assess devices, processes and cycles. Offered fall term - 2 hrs. lec.; 2 hrs. lab. *Prereq: MEEN 3310 and MEEN 3330.*

MEEN 3426. Engineering Statistics 3 sem. hrs.

This course covers the solution of non-deterministic problems in engineering along with application of statistics to engineering effort in areas such as design, tolerancing, material selection, process

selection, and reliability and quality controls. The course will also cover the application and limitations of inferential statistics in engineering. Offered spring term. *Prereq: MATH 1451.*

MEEN 3443. Manufacturing Engineering 3 sem. hrs.

The types of processes available to manufacture various products. The characteristics of these processes and how they interact with design requirements, tolerances, safety and the environment. Integration of basic concepts into complete processes. Determination of the process to manufacture various assigned products. Offered spring term. 2 hrs. lec., 2 hrs. lab. *Prereq: MEEN 2460.*

MEEN 3460. Materials Selection in Mechanical Design 3 sem. hrs.

Design methodology and the criteria for the selection of materials from the four classes of materials (metals, plastics, ceramics and composites) are discussed. Criteria include processing requirements, mechanical properties, and environmental resistance. A rationale for selecting materials based on materials selection charts is presented. The process-structure-property relationship for ferrous and non-ferrous alloys, plastics, ceramics and composites is presented from the point of view of understanding selection criteria. Considerations of cost and availability are also taken into consideration. Offered fall term. 2 hrs. lec.; 2 hrs. lab. *Prereq: MEEN 2460.*

MEEN 3991. Co-op Work Period 1 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Offered every term. Fee. SNC/UNC grade assessment.

MEEN 3992. Co-op Grading Period 1 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

MEEN 3993. Co-op Work Period 2 0 sem. hrs.

Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3993, 3994, etc. Offered every term. Fee. SNC/UNC grade assessment.

MEEN 3994. Co-op Grading Period 2 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

MEEN 4220. Intermediate Dynamics 3 sem. hrs.

Develop an understanding of the principles of 3D rigid body kinematics (motion) and kinetics (forces and accelerations). Use these principles to analyze the dynamic behavior of mechanical systems. Learn to use analytical mechanics tools including virtual work and Lagrange's method. Develop a systematic approach for solving engineering problems. *Prereq: MEEN 2120*

MEEN 4230. Intermediate Mechanics of Materials 3 sem. hrs.

Review of beam theory; asymmetric bending, shear center, thin-walled sections; torsion of non-circular sections, open and closed thin-walled sections; energy methods, Castigliano's second theorem, statically indeterminate structures, internal static indeterminacy; curved beams.

Prereq: CEEN 2130 or MEEN 2130.

MEEN 4240. Polymers and Polymer Composites 3 sem. hrs.

Introduction to physical/chemical structure of polymers, polymer characterization, polymer material properties and mechanical testing methods, elastic and viscoelastic polymer response, processing methods, composite materials, and the selection of polymers in design applications.

Prereq: CEEN 2130 or MEEN 2130.

MEEN 4245. Fatigue and Fracture Mechanics 3 sem. hrs.

Application of fatigue and fracture models to engineering design. Stress-life (high-cycle), strain-life (low cycle), and fatigue crack growth models for fatigue. Introduction to linear elastic fracture mechanics. Statistical considerations in failure. Fail safe design practices. Course includes illustrative case studies. *Prereq: CEEN 2130 or MEEN 2130.*

MEEN 4250. Design of Machine Elements 2 3 sem. hrs.

Detailed design of gears and cams. Integration of dynamics into design of machinery is emphasized. Topics include balancing of machinery, selection of motors and critical frequency analysis, and miscellaneous power transmission components. Use of spreadsheets and computer programs to assist in the design of various components.

Prereq: MEEN 3250 or equiv.

MEEN 4265. Intermediate Finite Element Methods 3 sem. hrs.

Application of finite element method (FEM) to static and dynamic mechanical systems. Introduction to commercially available FEM programs.

Prereq: MEEN 3260.

MEEN 4270. Physical Systems Modeling 3 sem. hrs.

Principles of modeling of physical systems, including devices and processes. Development of models of physical systems: mechanical, electrical, fluid, thermal and coupled systems. Time-dependent behavior of interconnected devices and processes. Computer-based modeling and simulation of physical systems. Identification using models and measured data. Introduction to control systems analysis and design.

Prereq: MATH 2451.

MEEN 4275. Mechatronics 3 sem. hrs.

Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electronics, control engineering, and computer science, all integrated through the design process. This course covers mechatronic system design, modeling and analysis of dynamic systems, control sensors and actuators, analog and digital control electronics, interfacing sensors and actuators to a micro-computer/microcontroller, discrete and continuous controller design, and real-time programming for control. *Prereq: MEEN 3270 and MEEN 3220.*

MEEN 4310. Internal Combustion Engines 3 sem. hrs.

Fundamentals of design and operation of internal combustion engines and how these affect performance, fuel requirements, and environmental impact. Study of fluid flow, thermodynamics, combustion, heat transfer and friction phenomena, and fuel properties relevant to engine power, efficiency and emissions. Examination of spark-ignition, diesel, stratified charge, HCCI and mixed-cycle engines.

Prereq: MEEN 3340.

MEEN 4330. Optics, Lasers and Spectroscopy in Engineering 3 sem. hrs.

Topical overview on the uses of optics, lasers, and spectroscopic measurement techniques in engineering and scientific disciplines. Technical content includes basic principles of geometric optics, principles behind and characteristics of laser operation, and linear spectroscopy. Emphasis on absorption and emission techniques for sensor development.

Prereq: PHYS 1004 or PHYS 1014.

MEEN 4350. Transport Phenomena 3 sem. hrs.

The subject of transport phenomena includes three closely related topics: fluid dynamics, mass transfer, and heat transfer. Fluid dynamics involves the transport of momentum, mass transfer is concerned with the transport of mass of various chemical species, and heat transfer deals with the transport of energy. In practice, rarely are these phenomena acting alone. Thus in this introductory course, these three topics are studied together so that a more cohesive understanding of these interrelated processes is developed. *Prereq: MEEN 3340.*

MEEN 4360. Intermediate Thermodynamics 3 sem. hrs.

This intermediate course will cover fundamentals of thermodynamics, including classical and statistical approaches with application to equilibrium and non-equilibrium, non-reactive and reactive systems. Topics relevant to micro/nanoscale and biological systems may be covered. *Prereq: MEEN 3340.*

MEEN 4410. Experimental Design 3 sem. hrs.

Application of statistical concepts to design engineering experiments to improve quality, production techniques, and reliability. Use and advantages of various models; factorial, fractional factorial, orthogonal arrays and fractional designs.

Prereq: MATH 4720, MEEN 2426, or cons. of instr.

MEEN 4420. Failure Analysis 3 sem. hrs.

Methodology of failure analysis. Studies of brittle fracture, ductile fracture, fatigue, stress corrosion and electro-chemical corrosion as applied to the failure of metals. Involves some laboratory work and analyses of a variety of metallurgical failures.

Prereq: MEEN 3460 and CEEN 2130 or MEEN 2130.

MEEN 4430. Powder Metallurgy 3 sem. hrs.

The course introduces a modern technology with growing importance. It covers the basics of powder metallurgy with main emphasis on sintered steel. The primary topics covered are powder production, die compacting, sintering theory and practice, full density processing, properties under static and dynamic loading conditions. *Prereq: MEEN 2460.*

MEEN 4440. Processing and Forming of Materials 3 sem. hrs.

Heat and mass transfer, thermodynamics, and stress analyses involved in materials forming process. Solidification and castings, vapor deposition of thin films and coatings. Sintering of powders and aggregates. Mechanical forming and drawing, forging, swaging, rolling. Absolute reaction rate theory for polymerization and chemical processes. Fabrication techniques for composite materials.

Prereq: MEEN 2460.

MEEN 4450. Mechanical Behavior of Materials 3 sem. hrs.

Stress and strain relationships for elastic behavior. Theory of plasticity. Plastic deformation of single crystals and polycrystalline aggregates. Dislocation theory, fracture, internal friction, creep and stress rupture and brittle failure. *Prereq: MEEN 3460 and CEEN 2130 or MEEN 2130; or cons. of instr.*

MEEN 4475. Ergonomics 3 sem. hrs.

Ergonomics maximizes the health and safety of workers, while maintaining productivity and quality. This course covers biomechanical and physiologic aspects of workplace design, such as engineering anthropometry, cumulative trauma disorders, (including carpal tunnel syndrome), low back injuries, hand tool design and evaluation, methods of surveillance in industrial environments, modeling, and ergonomics guidelines. Laboratory sessions are offered to demonstrate ergonomic principles and also provide students with hands-on experience in collecting data and conducting experiments. Offered fall term. 2 hrs. lec., 2 hrs. lab. *Prereq: GEEN 1120 or equiv.; and MEEN 2426 or equiv.*

MEEN 4485. Welding Engineering 3 sem. hrs.

Arc welding physics, fundamentals of power supplies and welding circuits, fusion and solid-state welding processes, weld testing, analysis of welded joints, demonstrations using various processes.

Prereq: CEEN 2130 or MEEN 2130; and MEEN 3443.

MEEN 4570. Introduction to Biomaterials Science and Engineering 3 sem. hrs.

Introduction to the principal areas in Materials Science. Structure and bonding, crystallography and mechanical properties of materials. Techniques to study structure and properties of materials, structure and mechanical properties of bone and various implant materials and their mode of failures. Same as BIEN 4420. *Prereq: MEEN 2460.*

MEEN 4590. Engineering Fundamentals Review 1 sem. hr.

Review of basic science, mathematics, engineering science, and economics. Offered fall term. S/U grade assessment. *Prereq: Sr. stndg. Same as CEEN 4710.*

MEEN 4920. Principles of Design 3 sem. hrs.

Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). Offered Fall semester. 2 hrs. lec., 2 hrs. disc.

Prereq: Sr. stndg; Co-op students, Jr. stndg. Cross-listed with BIEN 4920, COEN 4920, EECE 4920.

MEEN 4931. Topics in Mechanical Engineering 3 sem. hrs.

Covers a unique perspective or in-depth topic in: energy conversion, mechanical analysis and design and manufacturing systems.

MEEN 4991. Co-op Work Period 3 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4991, 4992. etc. Offered every term. Fee. SNC/UNC grade assessment.

MEEN 4992. Co-op Grading Period 3 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

MEEN 4993. Co-op Work Period 4 0 sem. hrs. Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 4993, 4994 etc. Offered every term. Fee. SNC/UNC grade assessment.

MEEN 4994. Co-op Grading Period 4 1 sem. hr.

Grading for preceding co-op work assignments is accomplished by review of Employer Evaluation Forms, Work Exit Reports, and other materials as required during each term in school following a work period. Offered every term. No tuition is charged for Grading Periods. S/U grade assessment.

MEEN 4995. Independent Study in Mechanical Engineering 1-3 sem. hrs.

Undergraduate independent study project of either theoretical or experimental nature. *Prereq: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.*

MEEN 4998. Senior Design Project 3 sem. hrs. Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. Offered Spring semester. 2 hrs. lec., 2 hrs. disc. *Prereq: MEEN 4920. Cross-listed with BIEN 4998, COEN 4998, and EECE 4998.*

SPECIAL PROGRAM*ENGINEERING ETHICS AND VALUES***ENEV 1952. Ethics and Values Colloquium 1** 1 sem. hr.

The colloquium consists of a series of lectures, films, and discussions involving social problems with significant technical components, societal values and engineering ethics. Students are required to meet approximately three to four times during the term. S/U grade assessment.

ENEV 2952. Ethics and Values Colloquium 2 1 sem. hr.

The colloquium consists of a series of lectures, films, and discussions involving social problems with significant technical components, societal values and engineering ethics. Students are required to meet approximately three to four times during the term. S/U grade assessment.

ENEV 3952. Ethics and Values Colloquium 3 1 sem. hr.

The colloquium consists of a series of lectures, films, and discussions involving social problems with significant technical components, societal values and engineering ethics. Students are required to meet approximately three to four times during the term. S/U grade assessment.

ENEV 4952. Ethics and Values Colloquium 4 1 sem. hr.

The colloquium consists of a series of lectures, films, and discussions involving social problems with significant technical components, societal values and engineering ethics. Students are required to meet approximately three to four times during the term. S/U grade assessment.

ENEV 4995. Independent Study 1-4 sem. hrs.

Undergraduate independent study project of either a theoretical or experimental nature. Offered every term. *Prereq: Jr. stndg, 3.000 GPA, cons. of instr., and cons. of dept. ch.*