Widener University

School of Engineering

2011–2012 Graduate Catalog

School of Engineering
2011–2012 Graduate Catalog

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BOOKSTORES
Main Campus, 610-876-7300
Delaware Campus, 302-478-0606
Harrisburg Campus, 717-541-3905

BUSINESS OFFICES
Main Campus, 610-499-4150
Delaware Campus, 302-477-2207
Harrisburg Campus, 717-541-3905

CAMPUS SAFETY
Main Campus, 610-499-4201
Delaware Campus, 302-477-2200
Harrisburg Campus, 717-541-3948

FINANCIAL AID
Main Campus, 610-499-4174
Delaware Campus, 302-478-2209
Harrisburg Campus, 717-541-3961

LIBRARIES
Main Campus, 610-499-4066
Delaware Campus, 302-477-2244
Harrisburg Campus, 717-541-3926

REGISTRAR
Main Campus, 610-499-4141
Delaware Campus, 302-477-2009
Harrisburg Campus, 717-541-3904

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UNIVERSITY POLICY

It is the policy of Widener University not to discriminate on the basis of sex, age, race, national origin or ethnicity, religion, disability, status as a veteran of the Vietnam era or other covered veteran, sexual orientation, gender identity, or marital status in its educational programs, admissions policies, employment practices, financial aid, or other school-administered programs or activities. This policy is enforced under various federal and state laws, including Title VII of the Civil Rights Act of 1964 as amended by the Civil Rights Act of 1991, Title IX of the Education Amendments of 1972, Section 504 of the Rehabilitation Act of 1973, the Age Discrimination in Employment Act, and the Americans with Disabilities Act. Further, in compliance with state and federal laws, Widener University will provide the following information upon request: (a) copies of documents pertinent to the university's accreditations, approvals, or licensing by external agencies or governmental bodies; (b) reports on crime statistics and information on safety policies and procedures; and (c) information regarding gender equity relative to intercollegiate athletic programs—Contact: Senior Vice President for University Advancement, Widener University, One University Place, Chester, PA 19013, 610-499-4123. Comments or requests for information regarding services and resources for disabled students should be directed to: Director of Disability Services, Widener University, One University Place, Chester, PA 19013, 610-499-1266; or Dean of Students, Delaware Campus of Widener University, P.O. Box 7474, Wilmington, DE 19803, 302-477-2177.

Title IX of the Education Amendments of 1972 prohibits discrimination based on gender in educational programs and activities that receive federal financial assistance. Such programs include recruitment, admissions, financial aid, scholarships, athletics, course offerings and access, hiring and retention, and benefits and leave. Title IX also protects students and employees from unlawful sexual harassment (including sexual violence) in university programs and activities. In compliance with Title IX, the university prohibits discrimination and harassment based on sex in employment, as well as in all programs and activities. The university's Title IX coordinator monitors compliance with Title IX and its accompanying regulations. Individuals with questions or concerns about Title IX or those who wish to file a complaint of noncompliance may contact the university's Title IX coordinator. The U.S. Department of Education's Office for Civil Rights (OCR) is the division of the federal government charged with enforcing compliance with Title IX. Information regarding OCR can be found at: www.ed.gov/about/offices/list/ocr/index.html.

This publication contains information, policies, procedures, regulations, and requirements that were correct at the time of publication. In keeping with the educational mission of the university, the information, policies, procedures, regulations, and requirements contained herein are continually being reviewed, changed, and updated. Consequently, this document cannot be considered binding and must be used solely as an informational guide. Students are responsible for keeping informed of official policies and meeting all relevant requirements.

The university reserves the right and authority at any time to alter any or all of the statements contained herein, to modify the requirements for admission and graduation, to change or discontinue programs of study, to amend any regulation or policy affecting the student body, to increase tuition and fees, to deny admission, to revoke an offer of admission, and to dismiss from the university any student at any time, if it is deemed by the university to be in the best interest of the university, the university community, or the student to do so. The provisions of this publication are subject to change without notice, and nothing in this publication may be considered as setting forth terms of a contract between a student or a prospective student and Widener University.

ACCREDITATIONS & MEMBERSHIPS

Widener University is a member of the Association for Continuing Higher Education and is accredited by the Middle States Association of Colleges and Schools.

Widener University's graduate programs are additionally accredited by the following: AACSB International—The Association to Advance Collegiate Schools of Business (School of Business Administration), Accreditation Commission of ABET (School of Engineering), American Bar Association (School of Law), American Psychological Association (Doctor of Psychology and Clinical Psychology Internship), Commission on Accreditation for Healthcare Management Education (Master of Business Administration in Healthcare Management), Commission on Accreditation in Physical Therapy Education (Doctor of Physical Therapy), Commission on Collegiate Nursing Education (School of Nursing), Commission on Continuing Legal Education of the Supreme Court of Delaware (School of Law), Council on Social Work Education (Center for Social Work Education), National Association for Education of Young Children (Child Development Center), National Council for the Accreditation of Teacher Educators (Center for Education), Pennsylvania State Board of Nursing (School of Nursing), Pennsylvania Continuing Legal Education Board of the Supreme Court (School of Law), Pennsylvania Department of Education (Center for Education), Pennsylvania Department of Welfare (Child Development Center), Pennsylvania Private School Board (Center for Education).

Widener University's graduate programs hold membership in the following: Academic Council of the American Physical Therapy Association (Institute for Physical Therapy Education), American Society for Engineering Education (School of Engineering), Association of Engineering Colleges of Pennsylvania (School of Engineering), Association of University Programs in Health Administration (School of Business Administration), Association of American Law Schools (School of Law), Association of Graduate Liberal Studies Program (Master of Arts in Liberal Studies), Greater Philadelphia Engineering Deans Economic Development Council (School of Engineering), Engineering Deans Institute (School of Engineering), Engineering Research Council of the American Association of Engineering Societies (School of Engineering), Engineering Workforce Commission (School of Engineering), National Association of Schools of Public Affairs and Administration (Master of Public Administration), National Association of State Boards of Accountancy (School of Law), National Council for Schools and Programs of Professional Psychology (Institute for Graduate Clinical Psychology), National League for Nursing and the American Association of Colleges of Nursing (School of Nursing).

GENERAL INFORMATION

ENGINEERING ADMINISTRATION

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Nora J. Kogut, MBA
Assistant Dean
Rudolph J. Treichel, MBA
Assistant Dean and Director, Graduate Programs
Zhongping Huang, PhD
Chairman, Department of Biomedical Engineering
Charles R. Nippert Jr., PhD, PE
Chairman, Department of Chemical Engineering
Vicki L. Brown, PhD, PE
Chairman, Department of Civil Engineering
Bryen E. Lorenz, PhD
Chairman, Department of Electrical Engineering
Mark A. Nicosia, PhD
Chairman, Department of Mechanical Engineering

ENGINEERING GRADUATE PROGRAMS

Master of Engineering (MEng)†
Chemical Engineering*
Civil Engineering*
Electrical Engineering
Engineering Management*
Mechanical Engineering
Master of Engineering/
Master of Business Administration**

†Dual specialization available

****Environmental engineering option available***

*****Dual degree with School of Business Administration***

MISSION

Widener University's School of Engineering is dedicated to providing quality undergraduate and graduate education and to advancing the state of knowledge in engineering, with the aim of preparing graduates for successful professional careers.

EDUCATIONAL OBJECTIVES

The educational objectives of the various graduate programs are that its graduates will excel in industry, government, and academia, and will demonstrate a commitment to lifelong learning and professional development. By the time of graduation, students are expected to achieve the following educational outcomes:

- demonstrate in-depth knowledge and competence in the field of study.
- develop advanced skills in acquiring, evaluating, and integrating new knowledge.
- demonstrate ability to communicate effectively.
- demonstrate ongoing understanding of professional responsibility.

Each program offers a core of courses that emphasizes fundamentals, and a set of electives that adds specialization and practical application. It is the intent of these programs that all graduates be well equipped as engineering specialists or as professionally skilled program managers.

The dual MEng/MBA program is offered in conjunction with each of the engineering programs except engineering management. The student should consult the curricula in the respective major area to complete the dual program course sequence.

The School of Engineering reserves the right to cancel the offering of any course if the enrollment is below minimum levels.

SESQUICENTENNIAL ANNIVERSARY

In 2012, the School of Engineering will celebrate its 150-year anniversary of providing quality engineering education at Widener University. The first class of three engineers began their studies in the fall of 1862 and graduated from the Pennsylvania Military Academy (Widener's predecessor institution) with the degree of bachelor of civil engineering in 1867. To date, thousands of students have completed their bachelor's and master's degrees in a variety of engineering disciplines. They have gone on to practice engineering in every corner of the nation and around the globe.

ADMISSION REQUIREMENTS

All inquiries and subsequent submission of admission forms for graduate engineering certificate programs, master of engineering (MEng) programs, and the dual degree (MEng/MBA) program should be addressed to:

Office of Graduate Enrollment Management
Widener University
One University Place
Chester, PA 19013-5792

MASTER OF ENGINEERING PROGRAMS—A graduate candidate should hold a bachelor of science degree in engineering. Candidates who hold undergraduate degrees in related areas are also considered.

Admission into a graduate program as a full-time student is predicated on a cumulative grade point average (GPA) of at least 2.8 (based on a 4.0 system) from an EAC/ABET-accredited undergraduate program and a cumulative score of at least 1050 in the verbal and quantitative sections of the Graduate Record Examination (GRE). The GRE requirement may be waived for applicants with strong credentials.

Admission into a graduate program as a part-time student is predicated on a cumulative GPA of at least 2.8 (based on a 4.0 system) from an EAC/ABET-accredited program and relevant professional experience. Although the GRE is optional for part-time students, it may be helpful in the evaluation of credentials.

CERTIFICATE PROGRAMS—Applicants should hold a bachelor's degree in engineering, engineering technology, science, business, or related field (depending on certificate) with a minimum GPA of 2.5 in their undergraduate program or PE certification.

RECOMMENDATION LETTERS—Prospective students applying for admission into the graduate program must provide two letters of recommendation at the time of application submission.

CONDITIONAL ADMISSION—Students who graduate from unaccredited programs or whose academic record falls short of established standards but whose progress since graduation has demonstrated notable achievement may be admitted with condition. To satisfy particular deficiencies, the student may be required to take certain undergraduate courses and/or graduate courses and receive a grade of B or better in each of these courses. Conditional courses will be specified in the acceptance letter from the School of Engineering's Office of Graduate Programs.

INTERNATIONAL STUDENTS—International students should consult the International Student Services web page at www.widener.edu for international graduate student guidelines or contact the Office of International Student Services at Widener University, One University Place, Chester, PA 19013; phone: 610-499-4499.

International students are required to complete one semester of study in the school and degree into which they are matriculated before they can be admitted to a different school or degree program in the university. During the initial semester, international students may apply for admission to a different school or degree, seeking admission for the subsequent semester.

SPECIAL STUDENTS—Students who are not formal degree candidates are considered special or nonmatriculated students. They must complete all course work assigned to degree candidates and receive a grade. A special student may request a change in status to degree candidate. The request must be submitted in writing to the Office of Graduate Programs, School of Engineering. An approval will specify the courses accepted for the degree program and the time limit. A maximum of 9 credits may be accepted toward degree requirements.

AUDITING—Students will be permitted to audit courses in the graduate program with the approval of the instructor. No grade or credit is given for auditing a course and examinations need not be taken; however, the registration procedure and fee structure are the same as that for other students.

TRANSFER OF CREDIT—A maximum of nine credits in total from all sources may be transferred.

Transfer of Credit for Graduate-Level Courses: Transfer credit for previous graduate courses that have not been used to satisfy the requirements of another degree may be accepted toward degree requirements. Transfer credit is granted only at the time the student is admitted to the program. The subjects must form an integral part of the proposed program as approved by the student's advisor and have been taken within five years prior to matriculation. A grade of B or better must have been earned in these transfer courses. No more than three credits will be accepted for transfer after matriculation. Students must obtain written permission from their advisor/department chairman and the graduate program director prior to taking a course at another institution and must earn a grade B or better.

Transfer of Credit for Half-Course Modules and Professional Short Courses: Transfer credit for half-course modules or professional short courses will be considered on a case-by-case basis, according to the above guidelines. Transfer credit for professional short courses may be considered only upon evaluation of a student course portfolio for each course. The student course portfolio must include the course syllabus, course notes, completed homework assignments, and either examinations or one or more graded course project reports. Team project work must be designated as such. Portfolios will be evaluated by at least two faculty members from the department involved. One and one-half semester hours of transfer credit may be awarded for a professional short course of a minimum of 22.5 contact hours, including 1.5 hours of examination/evaluation time.

GRADUATE MANAGEMENT ADMISSION TEST—The Graduate Management Admission Test (GMAT) is required for the dual MEng/MBA program.

ACADEMIC CALENDAR

At the start of each semester, students should check their online CampusCruiser account for academic calendar and deadline information.

GRADING

The following grades and their associated grade points are used:

A	(4.0)	D+	(1.3)
A–	(3.7)	D	(1.0)
B+	(3.3)	F	(0.0)
B	(3.0)	I	(Incomplete)
B–	(2.7)	W	(Withdrawn)
C+	(2.3)	P/NP	(Passed/Not Passed)*
C	(2.0)	AU	(Audit: No credit)
C–	(1.7)		

*Only for courses offered on a pass/fail basis.
NOTE: Individual instructors may elect, at their discretion, not to use plus/minus grades.

The grade point value for a given course is the product of the semester hours for the course and the numerical value of the grade obtained. The GPA is the total grade points divided by the number of semester hours undertaken, and is based upon the graduate courses that are required for the master's degree programs as shown in the curricula, which follows.

The grade of I is given when a student has not completed course requirements because of excusable reasons. A student who receives a grade of I must arrange to make up all deficiencies with the instructor issuing the grade. If the work is not made up within one calendar year from the end of the semester in which the incomplete is received, the grade will be automatically converted to F, unless the course in question is a thesis research course or a dissertation research course. Upon completion of the requirements, the instructor will institute a change of grade. (Note: A student does not register again for a course in which the grade of incomplete has been received.) A student cannot be awarded a degree when there is an outstanding incomplete grade on the transcript, even if the incomplete is in a course not required in the degree program.

SATISFACTORY ACADEMIC PROGRESS—Master's candidates are required to maintain at least a B average. Courses for which grades lower than B– are received may be repeated only with the permission of the graduate committee. The new grade replaces the old for computation of the GPA, but both grades are recorded on the transcript. No more than two repetitions total and only one repetition per course are allowed.

A student whose academic performance is considered inadequate will be subject to dismissal from the program. Conduct inconsistent with the ethical and professional standards of the discipline, whether it occurs before or after matriculation, is also grounds for dismissal from the program. Such conduct includes academic fraud, which consists of any actions that serve to undermine the integrity of the academic process, including cheating, post-test alteration of answers, plagiarism, and electronic or computer fraud. A student dismissed for academic fraud may no longer enroll in the graduate programs of the university and may not apply for admission into another division of the university. Please see the section titled "Standards for Academic Integrity."

COURSE OFFERINGS

Graduate course offerings are published each semester by the Office of Graduate Programs.

DROP/ADD POLICY—Students taking a course in the School of Engineering may withdraw from the course at any time prior to the final examination and receive the grade of W. If a course does not include a final examination, the deadline for withdrawing from the course with a grade of W is the final class meeting for the course. Graduate students begin the withdrawal process by notifying their instructor and advisor in writing of their intent to withdraw. Students must submit a drop/add form to the Registrar's Office and the Office of Graduate Programs.

Students may add a course without special permission no later than one week after the semester has begun. If a student wishes to add a course after one week, written permission must be obtained from both the instructor and the appropriate department head.

LEAVE OF ABSENCE

Students who have not completed their programs of study and desire a leave of absence must apply to the Office of Graduate Programs specifying the duration of the requested leave. Such leave will normally be granted. A student who does not apply for a leave of absence and does not register for at least one course in a semester will be considered as withdrawn from the program. International students must contact the Office of International Student Services before pursuing a leave of absence.

REINSTATEMENT TO THE PROGRAM

Students who have withdrawn from the program may petition for readmission by filing a new application. Such requests must be sent to the Office of Graduate Programsno later than 30 days prior to the start of the semester in which the student expects to enroll.

REGISTRATION

Currently enrolled students may preregister for courses for the following semester during the preregistration period. Newly admitted students must register in accordance with the schedule published in the academic calendar. There is a late registration fee for failure to adhere to this schedule.

STUDENT STATUS

Students pursuing a program of studies in Widener's School of Engineering are considered to be full-time graduate students when they are enrolled in 9 or more credits of graduate study or in ENGR 691, 692, or 693 (thesis). It is recommended that students take no more than 12 credits of graduate study per semester. Students who enroll in at least 5 credits of graduate study are considered to be half-time students.

TIME LIMIT

All requirements for the master of engineering degree must be completed within seven years from the beginning of the first semester or within two years from the start of Thesis I (ENGR 691), whichever comes first. See "Thesis Regulations" and "Thesis Continuation" below. Students enrolled in the dual MEng/MBA program must complete all requirements within nine years.

THESIS REQUIREMENT

Students holding assistantships or fellowships may be required to submit a thesis, which carries six semester hours of credit. The thesis is optional for all other students. Those who do not elect to write a thesis must substitute nine semester hours of course work, appropriate in each case to the student's major.

THESIS REGULATIONS—The thesis (and the research upon which the thesis is based) represents six semester hours of credit. Instructions for thesis preparation, format, and scheduling may be obtained from the graduate program office. A thesis proposal is to be submitted to the advisor and to the director for Graduate Programs and External Relations for approval prior to the student's enrollment in ENGR 691 (Thesis I). Upon successful completion of ENGR 691, students must enroll in the immediately following semester in ENGR 692 (Thesis II). The student must complete the thesis within a two-year period from the start of Thesis I. An oral defense of the thesis must be presented at a faculty seminar prior to final acceptance. The final document must be completed within six months after the oral defense.

THESIS CONTINUATION—Students who have not completed their thesis after enrolling for two consecutive semesters must then register for ENGR 693, Thesis Continuation, for which no graduation credit is given. Students must register for ENGR 693 in all subsequent semesters until the thesis is completed. Under unusual circumstances, the student may be granted an extension to complete the thesis beyond the two-year limit, in which case the student must register for ENGR 693 every semester until the thesis is completed.

ORAL PRESENTATIONS—Requests to schedule oral thesis presentations must be submitted to the student's advisor in writing. No oral thesis presentations will be permitted in the period 30 days prior to the scheduled graduation date. For additional information, contact the Office of Graduate Programs.

GRADUATE COOPERATIVE EDUCATION

Widener University's School of Engineering offers an optional graduate-level cooperative educational experience to qualified students. The program is intended to supplement students' graduate studies while preparing them for employment in the professional sector. The minimum grade point average to qualify for the program is 3.0. Students must maintain a 3.0 or higher grade point average for the duration of the cooperative education experience. International students may participate in the graduate co-op program after their first year of full-time studies and after attending an orientation session. For information, visit www.widener.edu and access the School of Engineering's Graduate Cooperative Education web page.

STANDARDS FOR ACADEMIC INTEGRITY

ACADEMIC INTEGRITY STATEMENT

> Widener University strongly supports the concepts of academic freedom and academic integrity and expects students and all other members of the Widener University community to be honest in all academic endeavors. Cheating, plagiarism, and all other forms of academic fraud are serious and unacceptable violations of university policy. Widener University expects all students to be familiar with university policies on academic honesty and will not accept a claim of ignorance—either of the policy itself or of what constitutes academic fraud—as a valid defense against such a charge.

This statement was adopted by the Faculty Council on February 24, 1998, upon recommendation of the Academic Affairs Committee.

DEFINITION OF VIOLATIONS OF THE STANDARDS FOR ACADEMIC INTEGRITY

Violations of the Standards of Academic Integrity constitute academic fraud. Academic fraud consists of any actions that serve to undermine the integrity of the academic process, including:

- unauthorized inspection or duplication of test materials, cheating, attempting to cheat, or assisting others to cheat in a classroom test, take-home examination, final examination, or comprehensive/qualifying/candidacy examination.
- post-test alteration of examination responses.
- plagiarism.
- electronic or computer fraud.

Additionally, each university program may have specific acts particular to a discipline that constitute academic fraud.

DEFINITION OF PLAGIARISM

One of the most common violations of the Standards for Academic Integrity is plagiarism. Plagiarism can be intentional or unintentional. However, since each student is responsible for knowing what constitutes plagiarism, unintentional plagiarism is as unacceptable as intentional plagiarism and commission of it will bring the same penalties. In many classes, faculty members will provide their definitions of plagiarism. In classes where a definition is not provided, students are invited to follow the standards articulated in the following statement.

STATEMENT ON PLAGIARISM

PLAGIARISM—passing off the work of others as your own – is a serious offense. In the academic world, plagiarism is theft. Information from sources – whether quoted, paraphrased, or summarized - must be given credit through specific in-text citations. All sources used in the preparation of an academic paper must also be listed with full bibliographic details at the end of the paper. It is especially important that paraphrase be both cited and put into your own words. Merely rearranging a sentence or changing a few words is not sufficient.

PROCEDURES FOR STUDENTS ACCUSED OF VIOLATING THE STANDARDS FOR ACADEMIC INTEGRITY

Informal Process

- A faculty member who obtains evidence of academic fraud should inform the student of this evidence, either orally or in writing. The faculty member may also provide the student with the opportunity to respond to the charges. If the matter is resolved informally between the faculty member and the student, the faculty member must communicate in writing to the dean of his/her school or college the nature of the charges made against the student and how the matter was resolved.
- If the faculty member cannot resolve the matter satisfactorily with the student, he or she may file a formal complaint against the student through the office of the dean of the faculty member's school or college.

Formal process

- Upon receiving formal charges of academic fraud, the office of the dean of the school or college shall thereupon notify the student in writing of the complaint, the evidence upon which the complaint is based, the penalty to be imposed, and all rights of appeal.
- If a student wishes to contest the allegations of the complaint, he or she may do so according to the process stipulated in the by-laws of the school or college in which the alleged offense occurred. In such a case, the student will also be informed of the time and location of a hearing on the complaint and of all rights of appeal.
- Upon determination by the school/college committee that hears the initial appeal that sufficient evidence exists to support the allegations contained in the complaint, or in cases in which the student chooses not to contest the complaint, the prescribed penalty shall be imposed.
- The dean will notify the associate provost in writing of the name of the student who has been found to have engaged in academic fraud.
- Appeals beyond an individual school/college body may be made by the student to the university's Academic Review Board. Please see the following section for board duties. Appeal to the Academic Review Board must be initiated by the student through the Office of the Associate Provost.
- In the event a complaint is filed against a student alleging academic fraud and the student is not enrolled in the course in which academic fraud is alleged, action will be taken by the dean's office of the school/college where the student is matriculated.
- An "F" for academic fraud will supersede any other mark including a "W" for withdrawal. When a student is found to have engaged in academic fraud under Widener's academic fraud policies, that student is prohibited from exercising the repeat-of-course option to remove the "F" grade (given as a result of fraud) from the GPA calculation.
- A confidential, centralized listing of students disciplined for academic fraud will be maintained by the Office of the Provost. In the event of the filing of a complaint alleging a second offense, the student will be informed, in writing, by the Office of the Provost of such complaint. Names will be dropped from the list of first offenders upon graduation or at the end of seven years after the last attendance.
- The above articulated steps constitute due process when students are accused of academic fraud.

PENALTIES

- The minimum penalty for individuals found through the formal complaint process described above to have engaged in academic fraud will be failure in the course. For a second offense, the penalty will be failure in the course and expulsion from the university.
- For attempting to steal or stealing an examination for a course, students will be failed in the course and expelled from the university. For attempting to steal or stealing a comprehensive/qualifying/candidacy examination in a program, students will be expelled from the university.
- Programs that require comprehensive/qualifying/candidacy examinations may elect to impose the penalties of failure on the examination and expulsion from the university for individuals who cheat or attempt to cheat on the comprehensive/qualifying/candidacy examination.
- Individuals found through the formal complaint process described above to have engaged in academic fraud in the completion of a dissertation or thesis may be expelled from the university.

These policies and procedures were approved by Faculty Council on April 28, 2008.

ACADEMIC REVIEW BOARD

The Academic Review Board consists of the provost, the associate provosts, the deans of each school/college, the vice-chairperson of the Faculty Council, and the chair of the Faculty Council Academic Affairs Committee. Duties of the board include: (1) hearing petitions for the waiver of academic regulations that transcend a single school/college (e.g., withdrawal from a course); (2) serving as the appeal body in cases where there is an alleged violation of procedure in school/college Academic Council hearings.

ACADEMIC GRIEVANCE APPEAL PROCEDURE

If a student has a grievance concerning a class in which he or she is enrolled, he/she will first try to resolve the problem with the instructor of the class. If a student has a grievance concerning an academic requirement of the program (e.g., comprehensive examination, final clinical oral examination, clinical placements), he/she will first try to resolve the problem with the director of the program. If it is impossible to resolve the matter at this initial level, the grievance must be placed in writing. Then the student may appeal to the next higher level. The student should inquire in the office of the dean responsible for the course or program in question for the proper appeal procedure if the student's grievance is not resolved to the student's satisfaction after initial appeal to the instructor or the program director.

GRADUATION REQUIREMENTS AND AWARDING OF DEGREES

Students are responsible for knowing and meeting curriculum requirements as shown in this bulletin.

The master of engineering programs require a minimum of 33 credits without a thesis, or 30 credits with a thesis. The dual MEng/MBA program's credit requirements vary according to the undergraduate business courses completed. A savings of two or three courses results from the combining of the two degree programs. Please note that a waiver of any requirement for the degree must be approved in writing by the Office of the Dean of the School of Engineering. A cumulative GPA of 3.0 or better is required for graduation, and, if applicable, completion of all thesis requirements. A student may not graduate with more than two course grades lower than B–. A student may not graduate with a grade of F in any of the courses attempted.

Those who expect to receive the master's degree should make clear their intentions to their advisors. A student who completes requirements for the degree at the conclusion of either summer session will be awarded the degree in August of that year; **the student must submit a graduation petition online at www.widener.edu/registrar by March 1.** A student who completes requirements for the degree at the conclusion of the fall semester will be awarded the degree in December of that year; **the student must submit a graduation petition online at www.widener.edu/registrar by July 1.** A student who completes requirements for the degree at the conclusion of the spring semester will be awarded the degree in May of that year; **the student must submit a graduation petition online at www.widener.edu/registrar by November 1 of the previous year.** The university holds only one formal commencement in the spring to which August, December, and May graduates are invited.

A student who petitions for graduation and who, for whatever reason, is not awarded the degree is not permitted to 'walk-through' commencement and must re-petition.

DUAL SPECIALIZATION

A student may elect to pursue a dual specialization while achieving their master of engineering degree. Dual specialization requires a minimum of 42 credits without a thesis or 39 credits with a thesis. In such cases, students must satisfy all requirements of the two programs and complete an additional 9 credits in the second program.

ASSISTANTSHIPS AND FELLOWSHIPS

A limited number of graduate assistantships are available. Assistantship appointments require service to the School of Engineering via participating in research projects or assisting faculty in executing teaching assignments. The assistantships are awarded by the dean upon recommendation of the department. The amount of service does not ordinarily exceed 20 hours per week. Most students who accept assistantship appointments complete their course of study within two years. Tuition reimbursed for graduate assistants is considered taxable income in accordance with current Internal Revenue Service regulations.

Appointments to assistantships are made for one semester only, but may be renewed. Holders of such appointments must devote full-time work to their studies and assistantship commitments. They may not be employed elsewhere without the prior consent of the advisor and the director for Graduate Programs and External Relations. Thesis students who accept graduate assistantships and then request a conversion to the non-thesis option are reviewed on a case-by-case basis by the Dean's Office and may be subject to financial penalty.

The School of Engineering follows the statement of the Council of Graduate Schools in the United States, which is as follows: "In every case in which a graduate scholarship, fellowship, traineeship, or graduate assistantship for the next academic year is offered to an actual prospective graduate student, the student, if he [she] indicates his [her] acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his [her] appointment in order to accept another graduate scholarship, fellowship, traineeship, or graduate assistantship. However, an acceptance given or left in force after April 15 commits him [her] not to accept another appointment without first obtaining formal release for the purpose."

AWARDS

The Frank and Angela LaVerghetta Prize is awarded annually to a graduating master of engineering student who has secured the highest cumulative GPA. However, no award will be made if the highest GPA is less than 3.7. In case of a tie, professional contributions of the candidates will be considered in deciding the winner.

The Shirley Kornfield Memorial Graduate Prize is presented annually to the student graduating with a master of engineering in electrical engineering who has secured the highest cumulative GPA.

TRANSCRIPTS

Students in good financial standing can have copies of their transcripts forwarded to employers, agents, or institutions of higher education by contacting the Office of the Registrar. The first transcript offered on behalf of a student is provided without cost.

CAMPUS SAFETY

Widener is committed to the safety and security of all members of the Widener University community. The university's annual Campus Safety and Fire Safety Reports are on the Widener website

and contain information on campus security and personal safety, including crime prevention, university law enforcement authority, crime reporting policies, disciplinary procedures, and other campus security matters. The Campus Safety Reports contain statistics for the three previous calendar years on reported crimes that occurred on campus, in certain off-campus buildings and property owned and controlled by the university, and on public property within or immediately adjacent to and accessible from campus.

The Fire Safety Report contains information on fire safety systems in on-campus student housing facilities, the number of file drills held during the previous year, the university's policies on portable electrical appliances, smoking, and open flames in student housing facilities, the university's procedures for student housing evacuation in the case of a fire, policies regarding fire safety education and training programs provided to students and employees, a listing of persons or organizations to which fires should be reported, and plans for future improvements in fire safety. It also contains statistics (commencing with calendar year 2009) for the three most recent calendar years concerning the number of fires and cause of each fire in each on-campus student housing facility, the number of persons who received fire-related injuries that resulted in treatment at a medical facility, the number of deaths related to a fire, and the value of property damage caused by a fire.

The annual Campus Safety and Fire Safety Reports for the Main and Exton Campuses are available online at www.widener.edu by selecting "Quick Clicks" then "Campus Safety." The annual security reports for the Delaware and Harrisburg Campuses are available online at www.law.widener.edu by selecting "More Links," then "Campus Safety." If you would like a printed copy of these reports, contact the Campus Safety Office at 610-499-4203 to have a copy mailed to you. The information in these reports is required by law and is provided by the Campus Safety Office.

FINANCIAL AID

Widener University offers a wide range of financial aid programs. Financial information is available on the university's web site at www.widener.edu/about/administration/enrollmentservices/studentfinancialservices. The *Financial Aid Handbook* is located under "Forms and Publications" on this site.

Master of Engineering

CHEMICAL ENGINEERING

The chemical engineering graduate program offers advanced study, with core courses in thermodynamics, transport phenomena, reaction kinetics, and applied mathematics. A wide range of technical electives is available to accommodate the interests of the individual student. The program is intended to confer proficiency in process analysis, synthesis, and design. The environmental engineering option or emphasis in biotechnology via course work and thesis provide the background to apply advanced techniques of chemical engineering to problems in these areas, which are important fields of professional activity for chemical engineers. The thesis option provides additional flexibility—particularly for students pursuing a career in research and development. The option is also valuable for those who wish to carry out an experimental or computer software development program in an area of special interest to them.

CURRICULUM—REQUIRED COURSES	***Sem. hours***
Engineering Mathematics*	6
ENGR 621 Transport Phenomena	3
ENGR 623 Chemical Engineering Thermodynamics	3
ENGR 624 Applied Reaction Kinetics & Catalysis	3
Technical Electives	9
ENGR 691 Thesis I or Technical Elective	3
ENGR 692 Thesis II or Technical Elective	3
Technical Elective for Non-Thesis Students	3

**Choose two of the three engineering mathematics courses with the approval of the student's advisor.*

TECHNICAL ELECTIVES

Group I

ENGR 602	Process Dynamics in Environmental Systems
ENGR 604	Environmental Law for Engineers
ENGR 605	Advanced Water & Wastewater Systems
ENGR 622	Mass-Transfer Operations
ENGR 637	Environmental Planning & Assessment

Group II

ENGR 603	Topics in Surface Water Hydrology & Water Quality Modeling
ENGR 606	Waste Incineration & Energy Recovery
ENGR 607	Hazardous Waste Management
ENGR 608	Municipal Solid Waste Engineering Systems
ENGR 609	Air Pollution Control
ENGR 610	Groundwater Pollution Remediation
ENGR 611	Deterministic Optimization
ENGR 612	Stochastic Optimization
ENGR 614	Engineering Management I
ENGR 625	Bioseparations
ENGR 626	Process Modeling and Simulation
ENGR 681	Fluid Mechanics
ENGR 683	Heat Transfer
ENGR 684	Heat Transfer Processes
ENGR 686	Heating, Ventilating, & Air Conditioning
ENGR 694	Special Graduate Engineering Topics
ENGR 695	Independent Research

For students interested in the environmental engineering option: (1) A minimum of two technical electives must be selected from Group I; (2) thesis students must select an environmentally oriented research topic.

CIVIL ENGINEERING

The civil engineering program is designed to provide a balance of traditional civil engineering subjects with courses exploring innovative technologies currently evolving into specializations with significant professional activities. Technical electives make it possible either to concentrate study in traditional areas or to augment course work with emerging technologies. The group of required courses provides depth of knowledge and an analytical perspective that sets the specialized technical electives in context. The environmental engineering option provides the background to apply advanced techniques to environmental problems, an important area of professional activity for civil engineers.

The flexibility of the curriculum allows students to design a program of study tailored to individual career goals and to the demands of the ever-changing marketplace. Students entering the program are normally expected to have a bachelor's degree in civil engineering. However, in certain cases students with undergraduate backgrounds in related engineering or science disciplines may qualify for admission and will be considered on an individual basis.

CURRICULUM—REQUIRED COURSES ***Sem. hours***

Courses from Group I or Group II 15
Technical Electives 9
ENGR 691 Thesis I or Technical Elective 3
ENGR 692 Thesis II or Technical Elective 3
Technical Elective for Non-Thesis Students 3

Group I: Environmental/Water Resources

ENGR 601 Land Development
ENGR 602 Process Dynamics in Environmental Systems
ENGR 603 Topics in Surface Water Hydrology & Water Quality Modeling
ENGR 604 Environmental Law for Engineers
ENGR 605 Innovative Water & Wastewater Treatment Systems
ENGR 608 Municipal Solid Waste Engineering Systems
ENGR 610 Groundwater Pollution Remediation
ENGR 613 Geosynthetics
ENGR 637 Environmental Planning & Assessment
ENGR 641 Design of Water Distribution & Sanitary Sewer Systems
ENGR 642 Best Practices for Storm Water Management

Group II: Structures

ENGR 628 Repair & Rehabilitation of Constructed Facilities
ENGR 629 Bridge Inspection & Rehabilitation
ENGR 631 Advanced Structural Steel Design
ENGR 632 Advanced Reinforced Concrete Design
ENGR 633 Structural Mechanics (required)*
ENGR 634 Structural Dynamics (required)*
ENGR 635 Timber Design
ENGR 636 Finite Elements
ENGR 639 Structural Stability

**ENGR 633 and ENGR 634 are required courses for the Structures Core.*

TECHNICAL ELECTIVES

Any Environmental/Water Resources or Structures Core course not previously taken. Additional approved electives are listed below. Other courses may be substituted on an individual basis, where appropriate, with the approval of the student's advisor.

ENGR 600 Municipal & Civil Project Management**
ENGR 606 Waste Incineration & Energy Recovery
ENGR 607 Hazardous Waste Management
ENGR 609 Air Pollution Control
ENGR 611 Deterministic Optimization**
ENGR 612 Stochastic Optimization**
ENGR 614 Engineering Management I**
ENGR 615 Engineering Management II**
ENGR 616 Engineering Math I
ENGR 617 Engineering Math II
ENGR 618 Engineering Math III
ENGR 619 Technical Communications**
ENGR 621 Transport Phenomena
ENGR 622 Mass Transfer Operations
ENGR 625 Bioseparations
ENGR 643 Ground Improvement
ENGR 671 Applied Stress Analysis I
ENGR 672 Applied Stress Analysis II
ENGR 673 Experimental Mechanics
ENGR 674 Vibrations
ENGR 675 Mechanical Behavior of Materials
ENGR 680 Advanced Computational Methods
ENGR 681 Fluid Mechanics

***A maximum of two technical electives may be selected from among these courses.*

Students majoring in civil engineering who also wish to complete the environmental engineering option may do so by selecting "Environmental/Water Resources Core" courses and technical electives that also satisfy the environmental engineering option requirements (see page 13).

Students majoring in civil engineering who also wish to earn the Land Development Certificate may do so by selecting their technical electives from ENGR 600 and ENGR 601 and two electives that are also offered in the certificate program.

ELECTRICAL ENGINEERING

The electrical engineering program is designed to provide students with a choice of specialized fields of study. Students may select one of the following groups: modern communications, networking and mobile communications, hardware, or software. Students entering the program are expected to have a bachelor's degree in electrical engineering. However, students with other undergraduate backgrounds may qualify for admissions and will be considered on an individual basis.

CURRICULUM—REQUIRED COURSES	*Sem. hours*
Engineering Mathematics*	3
Technical Electives	6
One Course from Each Technical Group	12
ENGR 619 Technical Communications	3
ENGR 691 Thesis I or Technical Elective	3
ENGR 692 Thesis II or Technical Elective	3
Technical Elective for Non-Thesis Students	3

**Choose one from ENGR 616, Engineering Mathematics I, or ENGR 618, Engineering Mathematics III, with the approval of the student's advisor.*

TECHNICAL ELECTIVES

Students choose electives that meet their educational goals. Electrical engineering students may choose technical electives from the following: modern communications, networking and mobile communications, hardware, or software. Students must also select at least one course in engineering mathematics and one course in technical communications.

Modern Communications Group

ENGR 652 Wireless and Cellular Telecommunications
ENGR 657 Communications Systems
ENGR 659 Digital Signal Processing
ENGR 647 Satellite Communications
ENGR 648 Geographic Information Processing

Networking and Mobile Communications Group

ENGR 645 Optical Communication Systems
ENGR 649 Digital Network Switching
ENGR 650 Advanced Computer Network Design
ENGR 658 Computer Communications
ENGR 664 Simulation of Computer Systems
ENGR 689 Mobile Computing

Hardware Group

ENGR 644 Microwave Devices and Circuits
ENGR 655 Microelectronic Circuit Design
ENGR 656 Microelectronic System Design
ENGR 667 Design of Computer Structures
ENGR 669 Computer Architecture
ENGR 694Z Embedded Systems

Software Group

ENGR 654 Algorithms and Date Structures
ENGR 660 Operating System Kernel Internals
ENGR 661 Database Engineering I
ENGR 662 Knowledge Engineering Systems
ENGR 663 Object-Oriented Programming
ENGR 665 Telecommunications Software
ENGR 668 Computer Graphics
ENGR 670 Simulation of Business Processes
ENGR 687 E-Business Platforms

ENGINEERING MANAGEMENT

Students who have managerial positions or will be assuming managerial responsibilities will find this program especially attractive. It provides an opportunity to combine advanced engineering study with an introduction to the principles and tools of management and decision making. It may not be combined with the thesis option nor incorporated in the dual MEng/MBA program.

CURRICULUM—REQUIRED COURSES	*Sem. hours*
Engineering Mathematics*	3
ENGR 611 Deterministic Optimization	3
ENGR 612 Stochastic Optimization	3
ENGR 614 Engineering Management I	3
ENGR 615 Engineering Management II	3
Major Engineering Courses**	12
Management Electives**	6

**Choose one of the three engineering mathematics courses with the approval of the student's advisor.*

***Major engineering courses and management electives must have approval of the student's advisor.*

MECHANICAL ENGINEERING

The mechanical engineering program offers post-graduate study in traditional and modern specialties. The curriculum is designed to provide maximum flexibility according to each student's specific interests. The objective is to enhance professional skills through advanced technical courses that build upon a foundation of mathematical, experimental, and modern computational methods.

CURRICULUM—REQUIRED COURSES ***Sem. hours***

Engineering Mathematics*	3
Courses from Group I or Group II	6
Technical Electives	15
ENGR 691 Thesis I or Technical Elective	3
ENGR 692 Thesis II or Technical Elective	3
Technical Elective for Non-Thesis Students**	3

**Choose ENGR 617 (without approval of advisor) or ENGR 616 (with approval of advisor).*

Group I—Solid Mechanics

ENGR 671 Applied Stress Analysis I**
ENGR 672 Applied Stress Analysis II
ENGR 673 Experimental Mechanics
ENGR 674 Vibrations
ENGR 675 Mechanical Behavior of Materials
ENGR 676 Advanced Mechanical Design

*** Required for Group I.*

Group II—Fluid Thermal

ENGR 681 Fluid Mechanics
ENGR 682 Computational Fluid Mechanics & Heat Transfer
ENGR 683 Heat Transfer
ENGR 684 Heat Transfer Processes
ENGR 686 Heating, Ventilating, & Air Conditioning

TECHNICAL ELECTIVES

ENGR 611 Deterministic Optimization
ENGR 614 Engineering Management I
ENGR 616 Engineering Mathematics I
ENGR 617 Engineering Mathematics II
ENGR 618 Engineering Mathematics III
ENGR 621 Transport Phenomena
ENGR 633 Structural Mechanics
ENGR 634 Structural Dynamics
ENGR 636 Finite Elements
ENGR 639 Structural Stability
ENGR 640 Theory of Plates & Shells
ENGR 671 Applied Stress Analysis I
ENGR 672 Applied Stress Analysis II
ENGR 673 Experimental Mechanics
ENGR 674 Vibrations
ENGR 675 Mechanical Behavior of Materials
ENGR 676 Advanced Mechanical Design
ENGR 677 Acoustics & Noise Control
ENGR 680 Advanced Computational Methods
ENGR 681 Fluid Mechanics
ENGR 682 Computational Fluid Mechanics & Heat Transfer
ENGR 683 Heat Transfer
ENGR 684 Heat Transfer Processes
ENGR 685 Aerodynamics
ENGR 686 Heating, Ventilating, & Air Conditioning
ENGR 694 Special Graduate Engineering Topics
ENGR 695 Independent Research

DUAL MEng/MBA

This program is designed for students who wish to strengthen their engineering education with advanced work at the graduate level, and who have a sufficiently strong orientation toward management to invest substantial effort toward education in that area as well. The program is jointly administered by the School of Engineering and the School of Business Administration. At the completion of the program, the student is awarded both the master of engineering and master of business administration degrees.

The MEng/MBA program is available in all of the engineering majors except engineering management. By means of careful selection and coordination of courses to avoid overlap, the dual degree may be earned with a considerable saving in total time and credit requirements. The minimum total number of credits is 54 with thesis or 57 without thesis. All electives require the approval of the student's advisor.

The dual MEng/MBA requires separate applications for each degree program. Acceptance into both programs is prerequisite to acceptance as a dual MEng/MBA candidate.

CURRICULUM—REQUIRED COURSES ***Sem. hours***

SCHOOL OF ENGINEERING

Engineering Mathematics*	6
ENGR 611 Deterministic Optimization	3
ENGR 614 Engineering Management I	3
Major Engineering Courses**	12
ENGR 691 Thesis I***	3
ENGR 692 Thesis II***	3

**Choose two of the three engineering mathematics courses or choose one engineering mathematics course and one major engineering course with the approval of the student's advisor.*

***With approval of the student's advisor.*

****Three engineering electives may replace Thesis I & II.*

SCHOOL OF BUSINESS ADMINISTRATION

BUS 601 Leadership	1.5
BUS 602 Strategic Planning	1.5
BUS 611 Information Systems	1.5
BUS 612 Data Collection, Mining, & Analysis	1.5
BUS 620 Customer/Market Perspectives	1.5
BUS 630 Human Resource Focus	1.5
BUS 640 Process Management	3
BUS 650 Modeling & Forecasting	1.5
BUS 660 Financial Analysis	1.5
BUS 700 Managing for Results	3
Electives	6
Total	**24**

In addition to these courses, students must meet all prerequisite requirements and must complete 12 contact hours of noncredit workshops.

Prerequisites:

BUS 510 Quantitative Analysis	3
BUS 520 Accounting & Legal Concepts	3
BUS 530 Micro & Macro Economics	3
BUS 550 Organization & Management	1
BUS 560 Finance Foundation for Managers	3

LAND DEVELOPMENT CERTIFICATE

The land development certificate program gives the practicing professional a solid understanding of the fundamentals of the land development process, blending theory and practice to help develop the skills and understanding needed to succeed in this competitive business.

Admission Requirements

To be accepted in the program, candidates must:

- Have earned a bachelor's degree in engineering or engineering technology. Applicants with bachelor's degrees in related mathematics or science fields will also be considered.
- Have a minimum GPA of 2.5 in their undergraduate degree program, or have earned EIT/PE certification.

CURRICULUM—REQUIRED COURSES	***Sem. hours***
ENGR 600 Municipal & Civil Project Management	3
ENGR 601 Land Development	3

TECHNICAL ELECTIVES (choose two, limit one * course)

ENGR 604	Environmental Law for Engineers*
ENGR 605	Innovative Water & Wastewater Treatment Systems
ENGR 610	Groundwater Pollution Remediation
ENGR 613	Geosynthetics
ENGR 637	Environmental Planning & Assessment
ENGR 641	Design of Water Distribution & Sanitary Sewer Systems
ENGR 642	Best Mgmt Practices for Stormwater Control
ENGR 643	Ground Improvement
PA 640	Planning & the Public*

Program Completion Requirements

To earn the land development certificate, students must earn a minimum grade point average of 2.8.

Matriculation from Certificate into Degree Program

To matriculate from the land development certificate program into our master in civil engineering or engineering management programs, students must complete the certificate program with a B average.

TECHNOLOGY MANAGEMENT CERTIFICATE

This program is relevant for professionals who wish to gain further knowledge in the area of technology management in order to advance their careers. To earn a graduate level certificate in technology management, candidates must complete the four required courses totaling 12 credit hours at Widener University. These credits can also be applied toward the master of engineering degree.

The technology management certificate program gives the practicing professional a solid understanding of the fundamentals of the technology management process, blending theory and practice to develop the skills and understanding needed to succeed in a competitive business world. Participants who complete the certificate can expect to improve their skills in the areas of:

- Economic/operational planning
- Team/project management
- Communication of technical materials
- Analysis and decision making

Admission Requirements

Applicants should hold a bachelor's degree in engineering, engineering technology, science, business, or related field with a minimum GPA of 2.5 in the undergraduate program or PE certification.

CURRICULUM—REQUIRED COURSES	***Sem. hours***
ENGR 611 Deterministic Optimization*	3
ENGR 614 Engineering Management I	3
ENGR 615 Engineering Management II	3
ENGR 619 Technical Communications**	3

Note: ENGR 611, 612, 614, and 615 are required courses for the master of engineering degree in engineering anagement.

**ENGR 612 Stochastic Optimization may be substituted.*

***ENGR 619 is a technical elective.*

Program Completion Requirements

To earn a certificate in technology management, students must earn a minimum grade point average of 2.8.

Matriculation from Certificate into Degree Program

Students who complete the certificate program with a cumulative GPA of 3.0 are eligible to matriculate into the master of engineering in engineering management degree program.

ENVIRONMENTAL ENGINEERING OPTION

Students who are interested in developing a background in environmental engineering or who have responsibility for environmental matters within their firms will find a selection of courses within the environmental engineering option particularly attractive. Those majoring in chemical engineering, civil engineering, or engineering management may select this option. Those majoring in other areas of engineering may select environmental engineering courses to meet some of their elective requirements. Interested students should obtain written approval from their advisor.

REQUIRED COURSES: Two of the following

ENGR 602	Process Dynamics in Environmental Systems
ENGR 604	Environmental Law for Engineers
ENGR 605	Innovative Water & Wastewater Treatment Systems
ENGR 637	Environmental Planning & Assessment

TECHNICAL ELECTIVES: Minimum of two of the following

ENGR 603	Topics in Surface Water Hydrology & Water Quality Modeling
ENGR 606	Waste Incineration & Energy Recovery
ENGR 607	Hazardous Waste Management
ENGR 608	Municipal Solid Waste Engineering Systems
ENGR 609	Air Pollution Control
ENGR 610	Groundwater Pollution Remediation
ENGR 622	Mass-Transfer Operations
ENGR 686	Heating, Ventilating, & Air Conditioning
ENGR 694	Special Graduate Engineering Topics
ENGR 695	Independent Research

Students may also choose from the other two required courses (if not previously taken).

ENGINEERING COURSES

ENGR 600 MUNICIPAL AND CIVIL PROJECT MANAGEMENT

This course focuses on project management skills for conceptual planning, budgeting, decision making, estimating and scheduling, financing, and client relations. Other topics include project feasibility and market forces; project delivery teams and the role of owners, developers, and contractors; the plan submission and review process; and project monitoring and control. Private versus public clients, dealing with the public, and professional liability are also covered, as is project evaluation and close-out. *3 semester hours*

ENGR 601 LAND DEVELOPMENT

This integrated theory and applications course focuses on urban area site planning, including the methodology used to subdivide, develop, or redevelop a property. Topics include site planning analysis, zoning, and municipal ordinances, subdivisions, site density, physical constraints, sustainability, environmental concerns, techniques for acquisition of data (mapping, traffic studies, ordinance requirements, and approval process), storm water management and erosion control, site grading, sanitary sewers and water systems, streets and parking lots, specifications and plans, and construction layout and inspection. *3 semester hours*

ENGR 602 PROCESS DYNAMICS IN ENVIRONMENTAL SYSTEMS

This course provides a fundamental understanding of the physical, chemical, and biological processes governing the fate and transport of pollutants in natural and engineered environmental systems. It serves as a basis for continued study in specialized areas such as air pollution control, water and wastewater treatment, hazardous waste management, and groundwater pollution remediation. Topics include material balances, transport processes, and chemical and biological reactions. Prerequisite: ENGR 617 or knowledge of calculus and differential equations. *3 semester hours*

ENGR 603 TOPICS IN SURFACE WATER HYDROLOGY AND WATER QUALITY MODELING

Selected topics in hydrologic engineering and water quality modeling, including frequency analysis of hydrologic events and rainfall-runoff analysis; design and analysis of storm sewers and storm water detention basins; water quality impacts of storm water runoff; development and application of water quality models to assess pollutant impact and transport in lakes, streams, and estuaries; analysis of pollutant reaction kinetics. Prerequisite: Undergraduate background in hydrology and water/wastewater treatment systems. *3 semester hours*

ENGR 604 ENVIRONMENTAL LAW FOR ENGINEERS

Local, state, and federal acts and regulations and their effect on environmental restoration and waste management. Topics include the history of environmental regulations and the environmental regulatory process, as well as the major requirements for compliance under the following environmental statutes: CAA, CWA, CERCLA, RCRA, SARA, TSCA, NEPA, SDWA, and others. Potential areas of modification of environmental laws. *3 semester hours*

ENGR 605 INNOVATIVE WATER AND WASTEWATER TREATMENT SYSTEMS

This course provides a background in the design and analysis of innovative water and wastewater treatment systems with an emphasis on the design of small systems for new developments

or retrofitting existing treatment systems. A review of conventional water and wastewater treatment practices is provided as an introduction. *3 semester hours*

ENGR 606 WASTE INCINERATION & ENERGY RECOVERY
This course covers the basic principles of combustion, including the theory of several processes, fundamentals and design of equipment for waste incineration, and design principles and their application to municipal and hazardous waste incineration facilities. *3 semester hours*

ENGR 607 HAZARDOUS WASTE MANAGEMENT
A comprehensive introduction to hazardous waste management, including laws and regulations, identification and analysis, risk assessment, and techniques and technologies for control and treatment. *3 semester hours*

ENGR 608 MUNICIPAL SOLID WASTE ENGINEERING SYSTEMS
This course covers generation, storage, collection, transport, processing, recovery, and disposal of municipal solid wastes, including economic and environmental aspects. Integrated municipal solid waste engineering is stressed. *3 semester hours*

ENGR 609 AIR POLLUTION CONTROL
This course covers the nature of the air pollution problem and its effects on the public at large; air quality standards; characterization of particles and aerosols; particle dynamics; principles and design of control devices including centrifuges, electrostatic precipitators, filters, and wet scrubbers. *3 semester hours*

ENGR 610 GROUNDWATER POLLUTION REMEDIATION
This course presents the nature of subsurface pollution and the sources of the pollution, along with techniques of analyzing pollution movement and monitoring. Methods of design for control of subsurface migration and treatment of contaminated groundwater are also covered. *3 semester hours*

ENGR 611 DETERMINISTIC OPTIMIZATION
Techniques for producing an optimal design of a deterministic system are presented. Topics include classical optimization methods, nonlinear and linear programming, search techniques, the transportation and assignment algorithm, dynamic programming, and geometric programming. Examples are taken from engineering and business applications. *3 semester hours*

ENGR 612 STOCHASTIC OPTIMIZATION
Modeling, analysis, and optimal design of stochastic engineering, management, and operational systems. The techniques of operations research are used. Topics include steady state analysis of single and multiple server queues; economic decisions in queuing systems; stochastic inventory models and effect of set-up cost; Markov chains and Chapman-Kolmogorov equations; Markov decision problems; policy improvement and discounted costs; system reliability and redundancy; decision analysis under risk and uncertainty and decision trees; and simulation, random number generation, and the Monte-Carlo technique. Prerequisites: An introduction to probability, e.g., ENGR 611; ENGR 618 is recommended. *3 semester hours*

ENGR 613 GEOSYNTHETICS
This course covers applications of geosynthetics including geotextiles, geogrids, geomembranes, geonets, geocomposites, and geosynthetic clay liners. Geosynthetics functions and mechanisms including separation, filtration, drainage, reinforcement, and containment are also covered. Students study design with geosynthetics for roadways, embankments/slopes, earth retaining structures, landfills, and site remediation. Prerequisite: Undergraduate soil mechanics course. *3 semester hours*

ENGR 614 ENGINEERING MANAGEMENT I
This course introduces students to the fields of management and business analysis in both industrial and consumer markets. The course also exposes students to the multidisciplinary nature of engineering management and covers the different functional areas with an emphasis on the "engineering" manager. Topics include management tasks and responsibilities, organizational structures, managing change, ethical considerations, strategy formulation, decision-making processes, statistical analysis, mathematical models, forecasting profitability, budgets, and financial controls. The course integrates case studies and projects, as well as provides opportunities for students to develop their writing and communication skills. *3 semester hours*

ENGR 615 ENGINEERING MANAGEMENT II
The course builds upon the basic management skills developed in ENGR 614. Emphasis extends to the global economy and covers global operations, investment decisions, cost accounting, production planning, quality issues, marketing management, leadership, and team building. The course builds on case studies and projects within the engineering field. Written reports, conclusions, and recommendations are included with oral presentations. Prerequisite: ENGR 614. *3 semester hours*

ENGR 616 ENGINEERING MATHEMATICS I
Introduction to linear algebra, including vector spaces, linear dependence and independence, linear transformations, matrices, and determinants. Topics include solution of systems of linear equations and eigen-value problems; complex variables, power series, complex integration, and residue theorem; and Fourier series and transforms. Elements of numerical analysis, numerical methods for systems of linear equations, and interpolation are also covered. *3 semester hours*

ENGR 617 ENGINEERING MATHEMATICS II
Topics include vector calculus and differential operators; line and surface integrals; Green's theorem, Divergence theorem, and Stokes' theorem; ordinary differential equations; and initial value problems and linear boundary value problems. Partial differential equations and the solution of initial and boundary value problems are also covered. *3 semester hours*

ENGR 618 ENGINEERING MATHEMATICS III
Topics include probability and random variables; sets, events, and probability space; joint, conditional, and total probability; Bayes' theorem; combinatorics; distributions and densities; continuous and discrete distributions; stochastic processes; expected values and moments; conditional expectation; moment-generating and characteristic functions; joint distributions and densities; covariance matrices; statistical inference and decision-making with applications. *3 semester hours*

ENGR 619 TECHNICAL COMMUNICATIONS
This course provides practical experience in written and oral communication techniques for technical material. A major focus is analyzing audiences and purpose for individual situations: Audiences range from expert and technical to lay; purpose varies from simply describing and informing to deftly instructing and persuading. Through didactic materials, text examples, and online activities, students craft documents and presentations on their own topics. Students also review the practical elements of grammar and syntax critical for controlling flow, emphasis, and clarity. *3 semester hours*

ENGR 621 TRANSPORT PHENOMENA
Topics include continuum and molecular theories of matter; velocity distributions in laminar and turbulent flow; boundary-layer analysis; simultaneous momentum, energy, and mass transport; transport analogies; convective and radiative heat transfer; molecular and turbulent diffusion; simultaneous diffusion and chemical reaction. *3 semester hours*

ENGR 622 MASS-TRANSFER OPERATIONS
Topics include the theory of equilibrium stage and continuous-contact operations; equilibrium relationships; stage efficiencies and mass-transfer rates; selection of separation processes and equipment configurations; and applications to binary and multi-component distillation, gas absorption, liquid extraction, air-water operations, and adsorption. *3 semester hours*

ENGR 623 CHEMICAL ENGINEERING THERMODYNAMICS
Topics include equations of state for mixtures; thermodynamics of non-ideal solutions; phase equilibria in complex systems; chemical equilibria in homogeneous, heterogeneous, and electrolytic systems; thermodynamic consistency; estimation of thermochemical and thermophysical data; entropy and probability; the Third Law; thermodynamics of energy conversion; and introduction to irreversible thermodynamics. *3 semester hours*

ENGR 624 APPLIED REACTION KINETICS & CATALYSIS
Topics include reaction-rate theory; kinetics of complex homogeneous reactions; effects of temperature and residence-time distribution; characterization of porous catalysts; kinetics of heterogeneous catalytic gas-solid reactions; external and internal coupled transport processes in porous catalysts; design of fixed- and fluidized-bed catalytic reactors; kinetics of fluid-fluid reactions with applications to reactor design; and laboratory reactors, analysis of experimental data, and scale-up. *3 semester hours*

ENGR 625 BIOSEPARATIONS
This course is an exploration of the principles, approaches, and techniques relevant to the separation and downstream processing of biologically produced molecules. Protein purification, recovery of small biomolecules (amino acids and antibodies), and the isolation of primary metabolites will be covered. Particular attention will be paid to the physical chemistry of biological molecules in solution. This approach will result in the development of efficient separation techniques for biomolecules while maintaining biological activity. *3 semester hours*

ENGR 626 PROCESS MODELING & SIMULATION
Topics are modeling and simulation of chemical engineering systems including distillation columns, gas absorbers, chemical reactors, and heat exchangers. Process identification techniques are also studied. *3 semester hours*

ENGR 627 PERFORMANCE EVALUATION OF CONSTRUCTED FACILITIES
This course covers the techniques and methods of analysis for evaluating the performance of a wide range of constructed facilities including highways, bridges, dams, buildings, tunnels, sewers, water distribution systems, and landfills. Various instrumentation systems and/or observational techniques are included, along with sample analyses to determine both structural and functional performance. *3 semester hours*

ENGR 628 REPAIR & REHABILITATION OF CONSTRUCTED FACILITIES
There are a growing number of bridges, buildings, and special-purpose (e.g., towers, chimneys, pipelines) structures which have deteriorated over many years of service and/or as the result of unforeseen environmental conditions or too-long-deferred maintenance. In addition, better understanding of structural behavior under seismic loads has led to the identification of serious shortcomings in a significant number of structures constructed prior to the mid 1970s. This course investigates repair and strengthening techniques for masonry, concrete, wood, and steel structures; mechanics of behavior and methods of analysis/evaluation for beams, columns, walls, slabs, and connections; and construction methodologies. *3 semester hours*

ENGR 629 BRIDGE INSPECTION & REHABILITATION
A significant number of bridge structures, which performed well for many years, show deterioration under severe service and environmental conditions. These structures can remain serviceable with proper rehabilitation and maintenance. This course investigates inspection, repair, and strengthening techniques for various types of bridge structures. Topics include maintenance policy principles, types of distress, bridge inspection and diagnostic testing, bridge structure repair and strengthening methods, bridge foundation rehabilitation, and load capacity evaluation. *3 semester hours*

ENGR 630 ADVANCED COMPOSITES IN CONSTRUCTION
Advanced composites for use in the construction industry have begun to generate considerable worldwide interest and expectation. This course will provide an overview of how composites may be used as stand-alone structural shapes, and as reinforcement for prestressed and non-prestressed concrete. Course topics will include the physical and chemical properties of constituent materials and resins and the manufacturing processes commonly used in producing composite materials for the construction industry; engineering properties of typical structural composites; test methods and performance-based standards; techniques for analysis; design considerations and philosophy; serviceability and durability; applications of composite materials in large integrated structural systems, and for the repair and rehabilitation of deteriorated structures; barriers to implementation, legal/liability concerns, and economics. *3 semester hours*

ENGR 631 ADVANCED STRUCTURAL STEEL DESIGN
This course covers behavior and design of columns, beam-columns, and single and multistory frames with a review of the latest building specifications. Selected topics include the design of structural systems, system stability, torsion effects, deflection analysis, plate girders, building connections, composite construction, and computer-aided designs. Prerequisite: Undergraduate background in structural steel design. *3 semester hours*

ENGR 632 ADVANCED REINFORCED CONCRETE DESIGN
This course covers behavior, analysis, and design of reinforced concrete elements and structures for flexure, shear and diagonal tension, axial compression and bending, and development of reinforcement. Techniques for calculating deflections and a review of current ACI code requirements are also covered. Selected topics include torsion, slab systems, yield line analysis, and composite construction. Prerequisite: Undergraduate background in reinforced concrete design. *3 semester hours*

ENGR 633 STRUCTURAL MECHANICS
Students analyze framed structures using matrix flexibility and stiffness methods. Topics include analysis of structural systems using substructures, nonprismatic and curved members, secondary effects, elastic foundations, and plastic and large-deflection analysis. Prerequisite: ENGR 616 or knowledge of matrix algebra. *3 semester hours*

ENGR 634 STRUCTURAL DYNAMICS
This course covers the dynamic response of structures modeled as single degree of freedom systems, shear buildings, discrete multidegree of freedom systems, and distributed properties. Topics include earthquake analysis by response history and response spectrum, and structural dynamics in building codes. Prerequisite: ENGR 617 or knowledge of differential equations. *3 semester hours*

ENGR 635 DESIGN OF TIMBER STRUCTURES
Topics include basic wood properties and design considerations for a variety of timber structures; behavior and design of beams, columns, and beam-column members; plywood and glue-laminated members; design of structural diaphragms and shear walls; and connection design. *3 semester hours*

ENGR 636 FINITE ELEMENTS
This course covers mathematical foundations of the finite element method and its relation to the Rayleigh-Ritz method, including application of the finite element techniques to the field problem of a continuum, with special emphasis on the numerical aspects of the method. Element types include displacement-based isoparametric elements, and formulation of plane, three dimensional, and plate and shell elements. Prerequisite: ENGR 616 or knowledge of matrix algebra and numerical methods. *3 semester hours*

ENGR 637 ENVIRONMENTAL PLANNING & ASSESSMENT
This course provides tools for the planning of environmental management programs and the assessment of environmental impacts. Topics include sources of environmental degradation, economic implications, standards, environmental impact statements, and methods for the assessment of land, water, air, and noise pollution impacts. *3 semester hours*

ENGR 638 PRESTRESSED CONCRETE DESIGN
Topics are prestressed materials, methods, and systems; behavior and design of members subjected to axial forces, flexure, shear, and torsion; effect of various prestress losses; partial prestressing, load balancing, and composite design; anchorage-zone design; and applications to continuous beams and frames, slabs, and bridge design. Prerequisite: Undergraduate background in reinforced or prestressed concrete design. *3 semester hours*

ENGR 639 STRUCTURAL STABILITY
Topics include principles and theory of structural stability; analytical and numerical methods for the treatment of elastic instability; buckling problems in beams, columns and plate elements, and frames; lateral and torsional instability; and energy and numerical methods. Prerequisite: ENGR 616 or knowledge of differential equations and matrix algebra. *3 semester hours*

ENGR 640 THEORY OF PLATES & SHELLS
Topics include the classical theory of bending of thin plates of various shapes and boundary conditions; energy principles and approximate methods of solution; thick plates and large deflection theory; and membrane and bending theories of shells of revolution and shallow shells. *3 semester hours*

ENGR 641 DESIGN OF WATER DISTRIBUTION AND SANITARY SEWER SYSTEMS
This course covers the theory and practice of designing water distribution systems and sanitary sewer systems for municipalities. Topics include selection of pumps and design of pump stations, hydrodynamics of pipe flow, the design and analysis of water distribution networks, flow in open channels, and sanitary sewer design. Prerequisite: Undergraduate fluid mechanics course. *3 semester hours*

ENGR 642 BEST MANAGEMENT PRACTICES FOR STORM WATER CONTROL
This course provides a review of recommended best management practices (BMPs) for storm water control for new and existing developments, including the design of storm water conveyance systems, storm detention ponds for water quality and quantity control, infiltration and recharge zones, and riparian buffers for erosion control. *3 semester hours*

ENGR 643 GROUND IMPROVEMENT
This course covers the mechanisms of soil stabilization by mechanical methods (compaction, explosives, vibroflotation, vibroreplacement), hydraulic methods (groundwater lowering, preloading, electro-osmosis), physical/chemical methods (admixtures, grouting, freezing), and inclusions (geosynthetics, reinforcements). Prerequisite: Undergraduate soil mechanics course. *3 semester hours*

ENGR 644 MICROWAVE DEVICES & CIRCUITS
This course presents the basic principles, characteristics, and applications of commonly used microwave devices and techniques for analyzing and designing microwave circuits. Topics include aspects of plane wave propagation, reflection and transmission, transmission line theory, Smith charts, impedance matching, waveguides, microwave cavities, S-parameters, hybrid circuits, couplers, isolators, transistors, tunnel diodes, TEDs, ATTDs, linear beam tubes (Klystrons), strip lines, and microstrip. Prerequisites: Undergraduate background in electromagnetics and solid state electronics. *3 semester hours*

ENGR 645 OPTICAL COMMUNICATION SYSTEMS
This course explores the operation of generic optical communication systems through an in-depth treatment of both the individual system components, such as optical sources (LED/LD), detectors (PIN/APD), and optical fiber (Multimode, SI, GRIN, DSF), as well as the integrated system characteristics (rise-time, bandwidth, data rate, eye diagrams, attenuation, PB). In addition, the course will cover optical amplifiers (EDFA), which have been responsible for the current trend toward wave-division multiplexing (WDM) in long haul, large capacity data systems. Fundamental principles in semiconductor concepts, electromagnetic theory, communications theory, and electronics will be discussed. Prerequisite: Undergraduate background in electrical engineering recommended. *3 semester hours*

ENGR 647 SATELLITE COMMUNICATIONS
This course is an introduction to theory and applications of satellite communications. Topics include both geosynchronous and non-geosynchronous satellite orbits, ground station look angles, signal propagation, link budgets, noise models, modulation, coding, noise reduction, ground station systems, and applications. Special emphasis is placed on understanding and implementing the relevant calculations. *3 semester hours*

ENGR 648 GEOGRAPHICAL INFORMATION PROCESSING
This course presents computations, analytical methods, and graphical representation for geographical information systems (GIS). Topics include spherical trigonometry, data models, coordinated transformations, digital filtering, terrain mapping, analysis of attributes over terrain, and spatial interpolation. In homework assignments and classroom workshops, students use these computational methods for processing of geographic information. Applications to electromagnetic wave propagation, magnetic field surveys, and hydrology are offered as extended examples. Coursework requires the use of a mathematical analysis package. *3 semester hours*

ENGR 649 DIGITAL NETWORK SWITCHING
This course covers the following: Switching fundamentals—matrix, multistage, shared memory, bus, and multiple bus switching fabrics; blocking, strictly nonblocking, and rearrangeable nonblocking switches. Space-division, time-division, and combined space- and time-division switching. Controller-based and self-routing switching; synchronous, frame, and cell/packet switching; Clos, Benes, Banyon, Knockout, Multistage Batcher-Banyon, Tandem Banyon, shuffle, toroidal, and recirculating switches. Buffer strategies, cut-through switching, multicasting, and priority handling; optical switching. Throughput, delay, and complexity performance analysis and implementation issues. Switching architectures for telephone, local-area to broadband networks, asynchronous transfer mode, and communication satellites, and their interconnections. *3 semester hours*

ENGR 650 ADVANCED COMPUTER NETWORK DESIGN
Topics include data communication and high speed network essentials; in-depth study of physical data; network and transport layer protocols covering Ethernet, token ring, FDDI, X.25, frame relay, leased lines, ATM, SDLC, HDLC, LLC frames, MAC addressing, TCP/IP, IPX/SPX, AppleTalk, DECnet and other bridging, switching, routing techniques; connectivity from LAN to LAN, LAN to WAN, and WAN to WAN; design of internet and intranet connectivity using OP and other protocols; introduction to firewall and security; and network management, as time permits. Students will be encouraged to use COMMNET III for network simulation and testing. Prerequisite: ENGR 658. *3 semester hours*

ENGR 652 WIRELESS & CELLULAR TELECOMMUNICATION
Topics include mobile and fixed wireless systems—cellular and point-to-point technologies. Wireless LANs, wireless STM (synchronous transfer mode), wireless cable, wireless local loops, microwave and satellite systems, cordless telephones, PCS (personal communication systems), and multimedia and video mobile services. Cellular concepts for macro-, micro-, and picocellular networks; frequency reuse, hand-offs, channel interference. Radio propagation effects of reflection, diffraction and scattering; use of microwave, millimeter, and optical infrared frequencies; climactic effects, directional and multiple antennas. Large-scale propagation models of path loss in irregular terrain, urban areas, microcells, and buildings. Small-scale models of fading, time-delay spread, and Doppler spread due to multipaths, movement of transmitter/receivers, or of surrounding objects and transmission bandwidth; statistical models of fading. Digital modulation—QAM (quadrature amplitude modulation), MSK (minimum shift keying), Gaussian MSK, spread spectrum, adaptive and multicarrier modulation. Signal processing to improve quality; adaptive equalization, diversity techniques, block and convolutional coding, trellis-coded modulation. Access methods—time, frequency, and space-division, frequency hopping and code division, and random access packet radio. inter-networking, signaling, and national and international standards. Prerequisite: ENGR 657. *3 semester hours*

ENGR 654 ALGORITHMS & DATA STRUCTURES
Fundamental algorithms and data structures for list and tree processing and for sorting, searching, traversing, and backtracking are discussed. More advanced algorithms for engineering use, such as graph processing, inference engines, network flow, and shortest path algorithms are also covered. Extensive programming in a structured language is required. Prerequisite: Programming experience in a structured language, such as C, C++, Java, or Ada. *3 semester hours*

ENGR 655 MICROELECTRONIC CIRCUIT DESIGN
This course covers integrated circuit design and fabrication; devices and models; analog and digital circuit design, simulation, and fabrication layout. A special feature of this course is actual fabrication of student-designed integrated circuits. *3 semester hours*

ENGR 656 MICROELECTRONIC SYSTEM DESIGN
This course covers VLSI circuit design; hierarchic layout techniques; circuit building blocks, including computing elements; testing, and testability design. A special feature of this course is laboratory testing of integrated circuits fabricated in ENGR 655. Prerequisite: ENGR 655. *3 semester hours*

ENGR 657 COMMUNICATIONS SYSTEMS
This course is an advanced level presentation of the fundamental concepts employed in modern communications. Topics include linear and nonlinear analog modulation; pulse code modulation methods; digital modulation (OOK, PSK, FSK, etc.), and coding methods; system concepts and system performance in the presence of noise. Prerequisite: Knowledge of Fourier analysis, probability, and statistics through appropriate course work. *3 semester hours*

ENGR 658 COMPUTER COMMUNICATIONS
Students learn advanced concepts in modern computer communications systems with emphasis on the OSI layered protocol model, including an introduction to network software modules. Additional topics include physical layer standards, bit stuffing and error control through checksums and protocol design with Petri-net modeling in the data link layer, the functions of repeaters and bridges, and the development of routing algorithms in the network layer, as well as shortest path and maximal flow algorithms. Treatment of the transport layer includes an introduction to the control protocol and internet protocol (TCP/IP). A special feature of the course is an introduction to the use of commercial network simulation tools. *3 semester hours*

ENGR 659 DIGITAL SIGNAL PROCESSING
Topics include a review of sampling; properties of discrete-time signals and linear systems; Fourier analysis of continuous and discrete-time signals; the z-transform and its properties; sampling in time and frequency; the discrete-time Fourier transform (DFT); implementation of FIR and IIR discrete-time systems; design of FIR and IIR digital filters. Prerequisites: Knowledge of the continuous-time Fourier transform; some familiarity with discrete-time systems and the z-transform is recommended. *3 semester hours*

ENGR 660 OPERATING SYSTEM KERNEL INTERNALS
Topics include architecture, algorithms, and data structures of the kernel, the inner core of an operating system, with primary study of UNIX and examples from other operating systems, such as Windows. Operating system layered design; relation of the kernel to the hardware, shells, program libraries, system call interfaces, and user programs. Entry into the kernel through system calls and hardware interrupts; interrupt vector table/system control block. Timesharing concepts, clocks, quantum (time slice), context switching, clock interrupt handler. Process definition, properties, and states (user mode, kernel mode, sleeping, swapped, preempted, zombie, etc.). Kernel process data structures; virtual addressing, paging and swapping policies. Creation of child processes using system calls (fork and exec). Shell operation and kernel start-up. Algorithms and data structures for scheduling processes. Software signal mechanism. Kernel implementation and uses of interprocess communication—pipes, messages, semaphores, shared memory, sockets. Other possible topics include file and I/O subsystems and device drivers, and

extensions for distributed and real-time operating systems. *3 semester hours*

ENGR 661 DATABASE ENGINEERING I
Topics include database systems theory and applications to engineering problems; hierarchical, network, and relational database models; relational query languages, optimization of relational queries, and relational normalization; deductive, object-oriented, and distributed databases; and issues of security and integrity. *3 semester hours*

ENGR 662 KNOWLEDGE ENGINEERING SYSTEMS
Topics include representation of knowledge, interface through formal logic, expert systems, inexact knowledge, Baysian interface, fuzzy logic, frame-based systems, neural networks, and the engineering design of interface systems, with examples. Some knowledge of computer programming is strongly recommended. *3 semester hours*

ENGR 663 OBJECT-ORIENTED PROGRAMMING
This course covers abstraction and object-oriented programming and their role in achieving software reusability, assuring software quality and, where applicable, safety, as in medical, communication, military, and robotics applications. Extensive laboratory examples and exercises. Prerequisite: ENGR 654 or extensive C++ experience. *3 semester hours*

ENGR 664 SIMULATION OF COMPUTER SYSTEMS
This course will present the techniques needed for simulation of mobile computing systems. This includes the generation of random variables for simulation, modeling, and evaluation of mobile computing configuration. Results will be displayed using object-oriented graphical methods with a commercial simulation language. An extensive simulation project will be completed during the course. Prerequisite: Knowledge of probability and statistics. *3 semester hours*

ENGR 665 TELECOMMUNICATION SOFTWARE
This course covers software system design and implementation for telecommunication systems and components, with a focus on optimizing software performance. Software for layered communication protocols, including finite-state machines for protocol implementation, buffer pool management, timer service routines, interlayer interfaces, and application program interfaces. Interrelated operating system mechanisms, including process models (context switching vs. procedure calls), interprocess communication, remote procedure calls, process scheduling and priority. Use in telecommunication software of linked lists, queues, stacks, tables and control blocks, and implementation of algorithms for tasks such as event handling using software clocks, delta lists, and timing wheels, message fragmentation and reassembly, encryption and cyclic redundancy coding. Software design of high speed protocols for lightwave networks, and multiprocessor implementation of protocols. Telephone network software for call processing, control of modern distributed switching systems, Signaling System No. 7 protocol and the services it supports, such as the Advanced Intelligent Network, mobile roaming capabilities, personal communication services, and asynchronous transfer mode. Software modems. Prerequisite: ENGR 654 or programming experience in a structured language. *3 semester hours*

ENGR 667 DESIGN OF COMPUTER STRUCTURES
Focus is on hardware design and test of digital systems at the logic and register levels of design, with emphasis on review of fundamental concepts; design of combinational, asynchronous and synchronous logic structures; programmable logic structures; algorithms and hardware descriptive languages, arithmetic algorithms, and arithmetic logic structures, both fixed and floating point; memories; error detecting and correcting codes (EDAC); logic and memory test; introduction to design of systems on a chip (SOC). Prerequisite: Undergraduate background in electronics and logic circuit design. *3 semester hours*

ENGR 668 COMPUTER GRAPHICS
Basic concepts of raster graphics algorithms and systems, geometrical transformations, 3D viewing, halftoning techniques, color models, illumination models, interactive graphics, and curve and surface representation. Advanced topics selected from shading and ray-tracing, visible-surface determination, representation of solids, texture modeling using fractals, image processing, and animation. Prerequisites: Programming experience in C/C++, ENGR 616, or undergraduate background in engineering or science including basic linear algebra. *3 semester hours*

ENGR 669 COMPUTER ARCHITECTURE
An overview of computer systems, architectural classification schemes, system attributes to performance, instruction set design and examples, arithmetic logic unit, memory system design, introduction to pipelining, pipeline performance measures, instruction and arithmetic pipelines, pipeline hazards, scheduling pipelines, RISC versus CISC architecture, introduction to interconnection networks, network topologies, interconnection design decisions, multiprocessors versus multicomputer, design and analysis of parallel algorithms, data flow and systolic array architectures. *3 semester hours*

ENGR 670 SIMULATION OF BUSINESS PROCESSES
This course will present methodologies for the efficient simulation of production and business operations. The theory of queuing systems and the simulation of discrete system processes will be developed. Upon completion of this course, students will understand the theoretical basis of discrete system simulation and will be able to use commercial simulation software to analyze and predict traffic and queuing patterns in such systems. *3 semester hours*

ENGR 671 APPLIED STRESS ANALYSIS I
Two- and three-dimensional analysis of the states of stress and strain in continuous solids. Derivation of the field equations and their application to the solution of classical problems; torsion of prismatic bars; analysis of axisymmetrically loaded members; stress concentration; and hertz contact stresses. Prerequisite/corequisite: ENGR 617. *3 semester hours*

ENGR 672 APPLIED STRESS ANALYSIS II
Advanced strength of materials solutions of elastic problems. Topics include bending of straight beams; bending of curved beams out of their initial plane; beams on elastic foundations; and bending of plates and shells. Prerequisite: ENGR 671. *3 semester hours*

ENGR 673 EXPERIMENTAL MECHANICS
Theory and application of electric strain gauge, photoelastic, and brittle lacquer methods of stress analysis for static and dynamic loadings. Laboratory exercises and demonstration are also covered. Prerequisite: ENGR 671. *3 semester hours*

ENGR 674 VIBRATIONS
Determination and solution of vibration problems involving multidegree of freedom and continuous systems by use of Newton's Laws, energy methods, and Lagrange's equations. Topics include the use of matrix methods and consideration of

generalized coordinates and normal mode analysis. Prerequisite/corequisite: ENGR 617 or undergraduate equivalent. *3 semester hours*

ENGR 675 MECHANICAL BEHAVIOR OF MATERIALS
A study of how loading conditions and environmental conditions can influence the behavior of materials in service. Topics include elastic and plastic behavior, fracture, fatigue, low and high temperature behavior; analysis of composite, honeycomb and reinforced materials; and designing with plastics. Prerequisite/corequisite: ENGR 671. *3 semester hours*

ENGR 676 ADVANCED MECHANICAL DESIGN
Design of mechanical components and systems common to many engineering applications using modern optimization techniques and related numerical methods. Elements of computer-aided design and reliability in engineering design are studied. *3 semester hours*

ENGR 677 ACOUSTICS & NOISE CONTROL
Wave motion and sound, propagation of sound waves, instrumentation and measurement, sound fields, machinery noise sources and control, and noise control criteria and regulations. *3 semester hours*

ENGR 680 ADVANCED COMPUTATIONAL METHODS
Development and application of computational methods for the solution of engineering problems; finite element and finite difference methods; applications to problems in solid mechanics, structural mechanics, vibrations, fluid mechanics, and heat transfer. *3 semester hours*

ENGR 681 FLUID MECHANICS
The basic equations of fluid mechanics are derived, and a variety of problems of importance in engineering practice are discussed. Topics include pipe and open channel flows, pipe networks, internal flows in pumps and turbines, external flows including low speed aerodynamics and drag reduction. Correct formulation of fluid flow problems for numerical solution, and the choice of effective computational methods for particular applications are stressed. Prerequisites: ENGR 617 and undergraduate fluid mechanics. *3 semester hours*

ENGR 682 COMPUTATIONAL FLUID MECHANICS & HEAT TRANSFER
Discretization of the equations of heat transport and fluid flow by finite difference and finite element methods. Computational features of various flow regimes C parabolic, elliptic, and hyperbolic equations. Solution of nonlinear equations. Optimization methods. Grid generation problems. Hands-on approach to computational solution of various prototype flow and transport problems. Prerequisites: Undergraduate fluid mechanics and heat transfer. *3 semester hours*

ENGR 683 HEAT TRANSFER
Fundamentals and applications of conduction, convection, and radiation heat transfer. The conservation equations, the heat conduction equation, steady and transient heat conduction in one, two, and three dimensions; formulation of convection problems, thermal boundary layers, similarity solutions, integral method; radiation view factors, view factor algebra, radiative exchange between gray diffuse surfaces. Prerequisites: ENGR 617 and undergraduate fluid mechanics and heat transfer. *3 semester hours*

ENGR 684 HEAT TRANSFER PROCESSES
Review of conduction, convection, and radiation heat transfer; film coefficients and overall-heat transfer coefficient; log-mean temperature difference; design of double-pipe and shell-and-tube heat exchangers; the split-flow exchanger; extended surfaces and the finned-tube heat exchangers; direct-contact heat transfer; furnace calculations. Prerequisite: Undergraduate heat transfer. *3 semester hours*

ENGR 685 AERODYNAMICS
The atmosphere, topics in fluid mechanics, two-dimensional air foil theory, subsonic and supersonic wing theory, drag, boundary layer control, ground effect machine. Prerequisite: ENGR 681. *3 semester hours*

ENGR 686 HEATING, VENTILATING, & AIR CONDITIONING
Fundamental concepts, A/C systems; psychrometry and its applications; comfort and environmental quality; space heating and cooling loads; pump and piping design; fan and duct design; room air distribution; direct contact heat and mass transfer, and the cooling tower; refrigeration. *3 semester hours*

ENGR 687 E-BUSINESS PLATFORMS
The design of e-commerce systems is discussed from the site design, logistics, accounting, and quality of service points of view. Site layout, customer interface, equipment architecture, and security are addressed. The logistics of supply chain management, manufacturing, distribution, and inventory control systems are discussed. Accounting issues include invoicing, payment systems, and returns; and interface to financial institutions will be detailed. Firewalls for site security, redundancy, speed, and encryption are explained as these pertain to quality of service. *3 semester hours*

ENGR 689 MOBILE COMPUTING
Mobile computing comprises wireless communication infrastructures and portable computing devices. The goal of this course is to provide a balanced mix of topics and open discussion about the technologies to address the challenges and solutions that facilitate mobile computing growth. Topics include mobile and wireless networking, operating systems and middleware, and product and application design and development. This course does not require previous programming experience. *3 semester hours*

ENGR 691 THESIS I
3 semester hours

ENGR 692 THESIS II
3 semester hours

ENGR 693 THESIS CONTINUATION
Faculty supervision of the thesis activity for those students having already completed two semesters of thesis work. (Fee basis: 1.5 semester hours.) *No semester hours*

ENGR 694 SPECIAL GRADUATE ENGINEERING TOPICS
Offering of special topics to graduate students when there is sufficient demand and faculty interest. *3 semester hours*

ENGR 695 INDEPENDENT RESEARCH
The student, under the general supervision of a faculty member, pursues an approved research topic of his or her own choice. The student is encouraged to investigate areas for which background material is not included in the regular curriculum. In this activity, the student should become progressively more independent, collecting and formulating data in the manner required of graduate thesis work. Enrollment is restricted to students recommended by a faculty member. *3 semester hours*

ENGR 698 GRADUATE COOPERATIVE EDUCATION
Students are placed in an engineering employment position for one semester, working with the Graduate Cooperative Education

Office. Positions are not guaranteed, as students are required to interview with and be hired by interested companies. Students are required to successfully complete their employment placement, meeting all job requirements. In addition, students must submit their job title and job description to the faculty advisor early in the semester and submit a written report and/or an oral presentation to receive a final grade at the close of the semester. The course is graded on a pass/fail basis only. The course may be taken a maximum of three times. Prerequisites: Cumulative GPA at or above 3.0. Students must have completed at least two full-time semesters in the graduate engineering program. (Credit hours **do not** satisfy graduation or degree requirements.) *3 semester hours*

DUAL DEGREE BUSINESS COURSES

BUS 510 APPLIED QUANTITATIVE ANALYSIS

This course is a study of modern mathematical techniques as used in business decision making. Topics include probability distribution, confidence intervals, hypothesis testing, and regression analysis. Prerequisite: None. *3 semester hours*

BUS 520 ACCOUNTING AND LEGAL ENVIRONMENT OF BUSINESS

This course is designed for graduate students with little or no prior experience in accounting. The course familiarizes students with the fundamentals of external financial reporting for business enterprises and not-for-profit entities. The financial accounting segment of the course focuses on the preparation, analysis, and limitations of financial statements in accordance with generally accepted accounting principles (GAAP). The conceptual framework that serves as the basis on which financial reporting standards are developed is also discussed. The managerial accounting segment of the course covers such internal reporting issues as break-even analysis, capital budgeting, cost behavior patterns, and cost allocation. The legal component of the course addresses the formation of different types of business entities (e.g., corporation and partnership) and the regulatory role that the SEC, PCAOB, and Sarbanes-Oxley Act of 2002 play in financial reporting. Prerequisite: None. *3 semester hours*

BUS 530 PRINCIPLES OF ECONOMICS

Directed toward students with little or no preparation in economics, this course focuses primarily on principles of microeconomic and macroeconomic analysis as applied to management decision making in both the private and public sectors. The microeconomic component of the course is devoted to examining the operations of output (product) and input (resource) markets as they relate to the demand and supply decisions by households, businesses, and trade with other countries. Topics include demand elasticities and revenue strategies, production and cost functions, price-output decision making in different types of market structures, input pricing and usage in various factor markets, and determinants of international trade. The macroeconomic component is based on analyzing the determinants of an economy's levels of output, income, employment, and prices. In addition, the overall economic impacts of government fiscal and monetary policies are studied. Topics include domestic income and product accounts, basic consumption and investment theories, fiscal and monetary policies for economic stabilization, inflation-unemployment tradeoff controversies, federal government budget deficits and debt management issues, and the macroeconomic impact of international trade. Prerequisite: None. *3 semester hours*

BUS 550 ORGANIZATION AND BEHAVIOR OF MANAGEMENT

This course provides students with the foundations of management. It covers the functions, roles, and skills of management; basic concepts in organizational behavior and dynamics; and an introduction to strategic management. The theories, models, and issues addressed serve as the building blocks of knowledge that students will need and use in more advanced courses in the core MBA program. Prerequisite: None. *1 semester hour*

BUS 560 FINANCE FOUNDATION FOR MANAGERS

The primary objective of this course is to expose students to a broad foundational survey of the finance discipline. This broad exposure is intended to enable participants to improve communication with finance professionals, contribute to financial decisions, and better understand financial statements. The course covers topics in the area of financial institutions, investments, and business finance. It is expected that at the end of the course, students will have received an integrated perspective of how business and individuals are affected by markets and institutions, and how markets and institutions can be used to achieve the goals of individuals and businesses. Prerequisite: None. *3 semester hours*

BUS 601 LEADERSHIP

To be competitive in the fast-paced global economy, business organizations must be lean, flexible, globally networked entities with a culturally diverse workforce. This course deals with the fundamental aspects of managing and leading in today's demanding business environment—how to work with and manage people on a one-to-one basis; how to influence group behavior and team effectiveness; how to design high-performing organizations; and how to motivate, lead, and empower people toward a common vision. The course helps students understand the core competencies needed to manage a contemporary organization and enables them to develop into ethical and effective leaders. This course must be taken in the first semester. Prerequisite: BUS 550 or equivalent. *1.5 semester hours*

BUS 602 STRATEGIC PLANNING

This course addresses the central challenge facing any business organization—how to generate and preserve a sustainable strategic advantage over competitors. It is a "big picture" course that helps students understand how the total enterprise works. Students learn how the environment impacts the firm and its prospects for success, how resources and capabilities serve as sources of competitive and corporate advantage, how corporate and business strategies create value for the firm, and how such value is captured at the bottom line. This course equips students with the tools for crafting a well-conceived strategy and executing it competently. Students develop skills in industry analysis, in sizing up a company's standing in the marketplace, and evaluating its ability to go head-to-head with the competition. Such skills are critical in a world where competitors are constantly reinventing themselves and their industries, where customers have become more powerful, and where technology is changing the way we do business. This course must be taken in the first semester. Prerequisite: BUS 550 or equivalent. *1.5 semester hours*

BUS 611 INFORMATION SYSTEMS

The Information Age has had profound implications on the structure, management, and strategies of modern organizations. This course examines these transformations with particular emphasis on information systems (IS) as an enabler and driver of corporate strategy, electronic business and inter-organizational information

systems, business intelligence and knowledge management, and the issues and challenges of managing information technology. This course is only offered in the fall semester and must be taken in sequence with BUS 612. *1.5 semester hours*

BUS 612 DATA COLLECTION, MINING, AND ANALYSIS
Data is at the core of effective business decision-making. This course focuses on data from collection and consolidation through analysis and modeling with particular emphasis on decision theory and data mining techniques. Ensuring data validity, reliability, security, and privacy are critical to protecting data—a vital organizational asset—and are emphasized. This course is only offered in the fall semester. Prerequisite: BUS 611. *1.5 semester hours*

BUS 620 CUSTOMER AND MARKET PERSPECTIVES
This course is designed to give students a solid conceptual understanding of the elements of marketing and marketing planning. Students learn to assess customer opportunities, implement solutions, and manage customer interactions through value creation strategies. Problems and practices in marketing are studied through in-depth reading of current literature and projects. This course is taken in sequence with BUS 630. Prerequisite: Foundation courses. *1.5 semester hours*

BUS 630 MANAGING HUMAN CAPITAL
This course focuses on creating an effective organization by improving the competence, coordination, and commitment of its most critical resource—people. The success of any competitive initiative within a company is determined by the capabilities, motivation, and behavior of its employees. Students learn to develop human resource systems that deliver the right mix of skills, knowledge, and motivation needed for organizational success, that enable employees across departments, businesses, and borders to coordinate decisions and actions for maximum performance, and that inspire employees at all levels to achieve the firm's strategic purpose. Students also acquire skills in organizational diagnosis, work design, performance management, and diversity and change management. This course is taken in sequence with BUS 620. Prerequisite: Foundation courses. *1.5 semester hours*

BUS 640 PROCESS MANAGEMENT
This course provides students with knowledge, skills, tools, and techniques to develop and improve processes and systems needed for their organizations to succeed in a highly competitive environment. The course integrates new concepts with material covered in other courses. Topics span all Baldrige criteria, starting with leadership and strategy and ending with improved business results. The course begins with a macro-overview of the markets in which organizations interact. Students learn how to create agile organizations that can rapidly identify customer needs and develop processes that facilitate the products and services demanded by customers.

A key part of this course is understanding and measuring processes so they can be improved to consistently meet customer requirements. To achieve this, process analysis and measurement techniques developed from a variety of disciplines, including quality improvement, management science, and managerial accounting, are discussed and demonstrated. These include process and work redesign, LEAN, TQM/CQI, Six Sigma, ISO9000, Baldridge Award Criteria, PDCA, and activity-based costing. In discussing these subjects, students learn how to apply tools such as control charts, Pareto charts, affinity and fishbone diagrams, and force field analysis.

To obtain an integrative perspective, students analyze the entire value chain. This includes the demand chain where they apply forecasting and marketing concepts to predict the quantity demanded and the shifts in what is demanded. Students also study supply chains to ensure they can deliver what customers want, when they want it, at a competitive price. Enterprise resource planning systems are covered later in the course as an integrating mechanism. Finally, students cover benchmarking as a tool that measures and compares performance, leading to improved results. Prerequisites: BUS 601, 602, 611, 612, 620, and 630. *3 semester hours*

BUS 650 MODELING AND FORECASTING
This course examines the fundamentals of effective modeling and statistical forecasting methods, with a major focus on the use of time series data. Through case study analysis, students apply concepts and techniques to actual business situations using real world data such as corporate revenue and monthly product demand. With students placed in the decision-making role, forecasting applications are studied in the areas of financial analysis, marketing, operations planning, and international management. This course is taken in sequence with BUS 660. Prerequisites: BUS 601, 602, 611, 612, 620, and 630. *1.5 semester hours*

BUS 660 FINANCIAL ANALYSIS
This course is designed to introduce the students to accounting and finance concepts as they relate to business valuation and mergers and acquisitions. The course focuses on financial reporting and tax issues associated with business combinations and consolidated financial statements. In addition, the course covers the topics of capital structure and cost of capital and applies these concepts to capital budgeting decisions in the context of mergers and acquisitions. Business valuation issues, including approaches to valuing a firm, are an important segment of the course. This course is taken in sequence with BUS 650. Prerequisite: BUS 601, 602, 611, 612, 620, and 630. *1.5 semester hours*

BUS 700 MANAGING FOR RESULTS
This capstone course integrates the knowledge and skills acquired throughout the program by applying them to improve organizational results in a variety of scenarios. Students address a series of case-based strategic challenges that include launching a new business venture, leading a turnaround effort, executing an acquisition, entering a new market in an emerging economy, responding to growing competition in a maturing industry, and revitalizing a firm facing rapid technological obsolescence. Students are expected to develop coherent and viable cross-functional solutions that reflect interdisciplinary knowledge and the ability to integrate and apply it appropriately. Prerequisite: All MBA Core. *3 semester hours*

ENGINEERING FACULTY

The faculty of the School of Engineering consists primarily of full-time professors, all of whom have earned their doctorates and many of whom have significant industrial experience. The faculty is supplemented by several competent adjunct professors from industry. In addition to teaching and research, faculty are active in professional societies as technical editors, as consultants to industry, and in offering continuing education seminars in areas of current technology.

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