College of Engineering

The objectives of the graduate programs in Engineering, Environmental Science and Studies, and Engineering Management are to:

1. Advance the state of art of the practice of engineering.
2. Advance the state of art of the teaching/learning process in engineering.
3. Contribute to the economic well being of the residents of Southeast Texas, the entire state and nation.
4. Improve the safety, health and environment of Southeast Texas, the entire state and nation.

The requirements of the various graduate programs in the College of Engineering are described below.

The College of Engineering offers graduate degrees at the master's and doctoral levels. At the master's level, both non-thesis and thesis degrees are available from each of five engineering departments. Non-thesis degrees offered are the Master of Engineering (M.E.) and the Master of Engineering Management (M.E.M.). The Master of Engineering Science (M.E.S.) offered by each engineering department; the Master of Science in Environmental Engineering and the Master of Science in Environmental Studies requires a thesis.

The Doctor of Engineering (D.E.) degree is offered through each of the five engineering departments. This degree requires a written field study documenting the findings of an advanced engineering design completed by the degree candidate.

The Doctor of Philosophy in Chemical Engineering, emphasizing methodology and technology development for sustainability of chemical and allied industry, environment, and economics, is offered through the Chemical Engineering Department in the College of Engineering.

Graduate degree programs are offered as follows:

Master of Engineering Management (M.E.M.)
Master of Engineering Science (M.E.S.)
Master of Engineering (M.E.)
Doctor of Engineering (D.E.)
Master of Science in Environmental Engineering (M.S.)
Master of Science in Environmental Studies (M.S.)
Doctor of Philosophy (Ph.D.) in Chemical Engineering

Master of Engineering Management (M.E.M.)

The Master of Engineering Management is a non-thesis degree program with all required courses offered after 4 p.m. Course work is designed to build onto the education received while completing an accredited bachelor's degree in engineering and the individual's professional experience. Hence, practicing engineers generally will not require undergraduate prerequisites.

A total of 36 credit hours are required at the graduate level. Included among these 36 credit hours are 15 hours of core courses required of all M.E.M. students. Course work in addition to the required core courses is tailored specifically to the needs of the student, but generally has approximately one-third of the courses in the general area of technical management, one-third in Business Administration, and one-third in the student's technical discipline such as Civil Engineering, Chemical Engineering, Electrical Engineering, Industrial Engineering or Mechanical Engineering.

Admission Requirements

Admission standards are designed to ensure that all enrolled students are qualified professionals serving in a leadership role in their engineering discipline. The four primary requirements are as follows:

1. B.S. in Engineering or Equivalent.
2. Graduate Record Examination (GRE) Scores (Verbal + Quantitative) = 1000 or more.
3. Two-to-five years of engineering experience in a leadership role.
4. Letter of recommendation for the program from someone in direct supervision over the applicant in his/her primary employment.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. Completion of a core program of 15 semester hours of specified courses.
3. Completion of a minimum of at least 36 semester hours from an approved list of courses. (See typical programs)

Step-by-Step Procedure

1. Obtain a Bachelor of Science Degree in Engineering.
2. Complete two-to-five years of professional practice in a position of leadership.
3. Apply for Admission to the Graduate College of Lamar University
   a. Complete Graduate application, obtainable by calling (409) 880-8356 or online at http://www.lamar.edu
   b. Take GRE and have scores sent to: Graduate Admissions, Lamar University, P.O. Box 10078, Beaumont, Texas 77710.
   c. Have all undergraduate transcripts sent to Graduate Admissions.
   d. Have letter of recommendation from supervisor sent to: Coordinator of Engineering Graduate Programs, P.O. Box 10032, Beaumont, Texas 77710.
4. In consultation with Coordinator of Engineering Graduate Programs, select graduate committee.
5. Complete 12 hours of course work including at least three core courses and apply for admission to candidacy.
6. Complete remaining course work specified in candidacy application
   a. Apply for Graduation
   b. Obtain copy of Comprehensive Examination policy from Industrial Engineering Department.
   c. Request and schedule Comprehensive Examination.
   d. Pass Comprehensive Examination
7. Graduate

Core Courses

1.	INEN	5369	Engineering Management
2.	INEN	5320	Statistical Decision-Making for Engineers
			or
	INEN	5370	Operations Research

3.	INEN	5316	Industrial Management
			or
	INEN	5376	Occupational Ergonomics
4.	INEN	5366	Advanced Engineering Economics
5.	ACCT	5200	Financial Accounting

Typical Program Options

Each student in consultation with an advisor should design a program tailored to meet his or her own specific educational objectives. The following typical program options are suggested. Substitutions and/or modifications to these programs can be accomplished with the approval of the student's advisor.

I. M.E.M. for Industrial Engineering

Technical Discipline

INEN 5370	Operations Research
INEN 5350	Production and Inventory Control
INEN 5345	Computer Integrated Manufacturing (CIM)
INEN 5376	Occupational Ergonomics

Technical Management

INEN 5369	Engineering Management
INEN 5366	Advanced Engineering Economics
INEN 5320	Statistical Decision Making
INEN 5315	Industrial Management

Business Administration

ECON 5200	Foundations of Economics
ACCT 5200	Financial Accounting
ACCT 5370	Managerial Accounting
MKTG 5200	Marketing Concepts

II. M.E.M. for Quality Management

Technical Discipline

INEN 5303	Regression Analysis
INEN 5312	Quality Improvement
INEN 5319	Design of Experiments
INEN 5363	Six Sigma

Technical Management

Same as Option I

Business Administration

Same as Option I

III. M.E.M. for Construction Project Management

Technical Discipline

CVEN 5308	Cost Optimization & Scheduling Engineering
CVEN 5320	Engineering Project Management
CVEN 5340	Foundation Engineering
CVEN 5381	Building Design/Construction
CVEN 6388	Computer Methods
ENGR 5301	Professional Engineering Practice
ENGR 5110	Construction Seminar
ENGR 5201	Construction Project Design

Technical Management

Same as Option I

Business Administration

Same as Option I

IV. M.E.M. for Environmental Management

Technical Discipline

CVEN 5317	Material Engineering Systems
CVEN 5331 Biological Wastewater Treatment	
CVEN 5325	Fundamentals of Air Pollution
CVEN 5329	Water Supply and Treatment

Technical Management

Same as Option I

Business Administration

Same as Option I

V. M.E.M. for Chemical Engineers

Technical Discipline

CHEN 5302	Transportation Phenomena
CHEN 5347	Material Science
CHEN 5357	Process Simulation
CHEN 5358	Advanced Process Simulation
CHEN 5360	Thermodynamic Process Industry
CHEN 5361	Process Optimization
CHEN 6340	Distillation
CHEN 6345	Fundamentals of Sustainability

Technical Management

Same as Option I

Business Administration

Same as Option I

VI. M.E.M. for Electrical Engineers

Technical Discipline

ELEN 5346	Digital Signal Processing
ELEN 5365	Image Processing
ELEN 5301-30	Computer Networks I
ELEN 5301-30	Computer Networks II
ELEN 5301-32	CMOS Digital IC DSN
ELEN 5301-32	VLSI Interconnects

Technical Management

Same as Option I

Business Administration

Same as Option I

VII. M.E.M. for Industrial Project Management

Technical Discipline

INEN 5323	IE Systems Design
INEN 5349	Production and Inventory Control
INEN 5354	Lean Manufacturing
INEN 5363	Six Sigma
INEN 5385	IE Design
INEN 5386	Industrial and Product Safety

Technical Management

Same as Option I

Business Administration

Same as Option I

VIII. M.E.M. for Mechanical Engineers

Technical Discipline

MEEN 5304 Advanced Engineering Analysis
MEEN 5389 CAD
MEEN 5309 Problems in Design and Finite Analysis
MEEN 5315 Theory of Elasticity
ENGR 5301-67 Turbomachinery
ENGR 5301-65 Optimization of Thermal Systems
ENGR 5301-64 Manufacturing Analysis
ENGR 5301-66 Materials Selection
ENGR 5301-69 Modeling and Simulation

Technical Management
Same as Option I

Business Administration
Same as Option I

Master of Engineering Science (M.E.S.), Master of Engineering (M.E.), and Doctor of Engineering (D.E.)

The Master of Engineering Science, Master of Engineering and Doctor of Engineering programs are administered by the Graduate Steering Committee. Students entering these programs are responsible to this committee until a permanent graduate committee including a chairman is selected and approved. The student should select an advisor and a permanent graduate committee must be formed before the student has completed 15 semester hours of graduate work. No credit toward a graduate degree will be granted unless approved by either the Graduate Steering Committee or the student's permanent graduate committee.

Core Course Categories for the M.E.S., M.E. and D.E. Programs:

Category	Course Number and Title	
1.	Mathematics/Statistics	
	ENGR 5301-07	Sp. Topics: Process Modeling – Neural Networks
	ENGR 5388	Special Topics: Engineering Systems Analysis
	INEN 5320	Statistical Decision Making for Engineers
	INEN 5303	Regression Analysis
	MEEN 5304	Advanced Engineering Analysis
	INEN 5305	Reliability
	INEN 5319	Design of Experiments
	ELEN 6314	Computer Control and Instrumentation
2.	Optimization/Management	
	ENGR 5301-05	Sp. Topics: Optimization of Chemical Processes
	ENGR 6349	Engineering Applications of AI and Expert Systems
	CVEN 6388	Comp. Mtds. of Engr. Project Management
	INEN 5370	Operations Research
	ENGR 5301-64	Sp. Topics: Optimization of Thermal/Mechanical Systems
3.	Simulation/Control	
	CHEN 5357	Process Simulation
	CVEN 5324	Models in Hydrological Systems
	ELEN 6358	Industrial Automation and Process Control
	INEN 5375	Simulation of Industrial Systems
	ENGR 5301-62	Special Topics: Control of Mechanical Systems

Master of Engineering Science (M.E.S.)

The Master of Engineering Science Degree requires the completion of 30 semester hours of graduate course work, including a thesis.

Admission Requirements

For admission to the program, the student must meet the following requirements:

1. The general requirements for admission to the College of Graduate Studies.
2. Hold a bachelor's degree in a field of engineering or related discipline with credit substantially equivalent to that required for bachelor's degrees at Lamar University.
3. These are minimum admission requirements. Individual departments may be more selective.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. A minimum of 3 semester hours (one course) from those courses listed above as core courses.
3. A minimum of 21 semester hours (seven courses) of electives. Additional core courses may satisfy part of this requirement.
4. Satisfactory completion and defense of thesis (ENGR 5390 and ENGR 5391).

Master of Engineering (M.E.)

The Master of Engineering Degree is a non-thesis 36 semester hour* program designed to suit the needs of the practicing engineer.

Admission Requirements

For admission to the program, the student must meet the following requirements:

1. The general requirements for admission to the College of Graduate Studies.
2. Hold a bachelor's degree in a field of engineering or related discipline with credit substantially equivalent to that required for bachelor's degrees at Lamar University.
3. These are minimum admission requirements and may be more selective for individual departments.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. Completion of one course from each of the three categories of core courses for a total of 9 semester hours of core course work. The core course categories and core courses are listed above.
3. A minimum of 27 semester hours* (nine courses) of electives. Additional core courses may satisfy part of this requirement.
4. Satisfactory completion of a final comprehensive examination.

**A graduate student who has passed the Fundamentals of Engineering Examination or a graduate student who is a Professional Engineer registered in the State of Texas (or registered in another state where requirements do not conflict with the provisions of the Texas Engineering Practice Act and are of a standard not lower than those specified in Section 12 of that Act) may satisfy course requirements by completing 24 semester hours of electives toward a total of 33 semester hours provided ENGR 6310 (Design Project) is included.*

Doctor of Engineering (D.E.)

The Doctor of Engineering Degree is designed to permit the practicing engineer to study practical engineering problems of a complex nature.

Admission Requirements

For admission to the program, the following requirements must be met:

1. The general requirements of the College of Graduate Studies.
2. The applicant must hold a Bachelor of Science degree in a field of engineering. The applicant must have an overall GPA and quantitative section of the GRE score which meets the following criteria: (50*GPA + GRE) must equal or exceed 800. International students must have a minimum TOEFL score of 530.
3. The applicant must hold a Master's degree or have completed at least 30 semester hours of course work at the graduate level in a field of engineering or a closely related discipline.
4. These are minimum admission requirements. Individual departments may be more selective.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. The student shall complete a residency of one year.
3. The student shall register for ENGR 6110, Professional Seminar, each semester in which the student is registered for more than six hours or in which the student is registered for field study. A minimum of 4 hours is required.
4. Completion of one course from each of the three categories of core courses for a total of 9 semester hours of core course work. The core course categories and core courses are listed above. Exceptions to this rule must be approved by the Director of Engineering Graduate Studies.
5. Completion of the diagnostic examination. This examination has the objectives of determining the student's qualifications for a doctoral program and to provide guidance for the selection of a study program. This examination must be completed before the student has earned 15 semester hours of course credit after admission to the program.
6. Completion of a minimum of 18 credit hours of field study preparatory courses in a concentration designed to form a cohesive degree plan and must be approved by the student's advisory committee. The field study preparation includes completion of one semester of ENGR 6320, Justification of Engineering Project.
7. Completion of candidacy examination. The purposes of this examination are to test the ability of the student to comprehensively relate the subjects of the study program and to ascertain the student's qualifications to perform the field study.
8. Completion of the field study. After the student is admitted to candidacy a formal engineering proposal must be presented to the doctoral committee. Upon committee approval of the proposed field study the work is initiated. Normally, 30 semester hours of field study is required.
9. Defense of field study. Upon completion of the field study a formal report with a standard thesis format shall be submitted to the committee and defended in an oral examination.

Master of Science in Environmental Engineering

Until recently, environmental engineers were primarily concerned with municipal water systems and sewage treatment facilities. The bulk of the course work dealt with the application of engineering solutions to human health problems. Today, the field includes the study of water quality, air quality and methods for disposing of toxic/hazardous wastes. Overall, environmental engineers are engaged in solving the large and complex environmental problems threatening the natural ecosystem.

The Master of Science in Environmental Engineering program is designed to provide engineers with the highly specialized chemical/civil engineering background needed by industry and by regulatory agencies on the federal, state and municipal levels.

Admission Requirements

For admission to the program, the student must meet the following requirements:

1. The general requirements for admission to the College of Graduate Studies.
2. Hold a bachelor's degree in a field of engineering which is equivalent to a bachelor's degree at Lamar University.
3. Because of the diversity of the scientific disciplines which are admitted to the environmental studies program, some students may be lacking in certain fundamental subject areas, usually undergraduate level courses in engineering, microbiology, basic chemistry, geology, and/or mathematics. These courses must be taken in addition to the curriculum required for the master's degree program.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. A minimum of 12 semester hours (4 core courses) from those listed below:

CHEM	5301	Special Topics in Environmental Chemistry[1]
CVEN	5325	Fundamentals of Air Pollution
CVEN	5329	Water Supply and Treatment
CVEN	5331	Biological Wastewater Treatment
CHEN	6344	Multimedia Transport of Pollutants
CVEN	6387	Hydraulics of Environmental Systems[2]

[1]with committee approval, an equivalent chemistry course may be substituted.
[2]with committee approval, Hazardous Waste Management (ENGR 6339) may be substituted.

3. A minimum of 15 semester hours (five courses) of designated electives from the list below or other approved electives:

BIOL	5301	Special Topic: Microbiology
BIOL	5430	Limnology
BIOL	5470	Ecology of Polluted Waters
CHEM	5411	Biochemistry I
CVEN	5324	Models in Hydrological Systems (HEC-HMS, HEC-RAS)
CVEN	5326	Hydrologic and Hydrodynamic Processes
CVEN	5338	Solid Waste Management
CHEN	5342	Reactor Design for Environmental Systems
CVEN	5343	Industrial Waste Treatment
CVEN	5351	Unit Operation in Environmental Engineering

GEOL	5301	Special Topic: Hydrogeology
CVEN	6339	Hazardous Waste Management
ENGR	6389	Computer-Aided Software Engineering (Geographic Information System)

4. Satisfactory completion and defense of thesis

Master of Science in Environmental Studies

The environmental studies program is designed for students who wish to continue to work in their scientific specialty but as it relates to environmental affairs. The degree is especially intended for individuals who wish to work in the evaluation, operations and/or regulatory aspects of the field as opposed to the design or engineering areas. Consequently, the program will provide an understanding of environmental problems and processes from the point of view of the chemist, biologist or geologist and provide the interdisciplinary perspective needed to cope with various environmental issues.

Admission Requirements

For admission to the program, the student must meet the following requirements:

1. The general requirements for admission to the College of Graduate Studies.
2. Hold a bachelor's degree in chemistry, biology, geology, the subdivisions of those fields e.g. microbiology, organic chemistry, hydrogeology, etc. or other closely related fields with credit substantially equivalent to that required for bachelors' degrees at Lamar University.
3. Some applicants to this program may be required to take undergraduate level courses in engineering, geology, microbiology, basic chemistry and/or mathematics. These courses must be taken **in addition to** those required for the masters program and will be selected in consultation with the advisor early in a student's graduate career.

Degree Requirements

1. All of the College of Graduate Studies general degree requirements.
2. A minimum of 6 semester hours (two graduate courses) in the student's science specialty.
3. A minimum of 12 semester hours (four core courses) from those listed below:

CHEM	5301	Special Topics in Environmental Chemistry[1]
CVEN	5325	Fundamentals of Air Pollution
CVEN	5329	Water Supply and Treatment
CVEN	5331	Biological Wastewater Treatment
CHEN	6344	Multimedia Transport of Pollutants
CVEN	6387	Hydraulics of Environmental Systems[2]

[1]with committee approval, an equivalent chemistry course may be substituted.
[2]with committee approval, Hazardous Waste Management (ENGR 6339) may be substituted.

4. A minimum of 9 semester hours (three courses) of designated electives from the list below or other approved electives:

BIOL	5301	Special Topic: Microbiology
BIOL	5430	Limnology

BIOL	5470	Ecology of Polluted Waters
CHEM	5411	Biochemistry I
CVEN	5324	Models in Hydrological Systems (HEC-HMS, HEC-RAS)
CVEN	5326	Hydrologic and Hydrodynamic Processes
CVEN	5338	Solid Waste Management
CHEN	5342	Reactor Design for Environmental Systems
CVEN	5343	Industrial Waste Treatment
CVEN	5351	Unit Operation in Environmental Engineering
GEOL	5301	Special Topic: Hydrogeology
CVEN	6339	Hazardous Waste Management
ENGR	6389	Computer-Aided Software Engineering (Geographic Information System)

5. Satisfactory completion and defense of thesis

Doctor of Philosophy (Ph.D.) in Chemical Engineering

Admission Standards

A minimum undergraduate GPA of 3.0/4.0 or a graduate GPA of 3.5/4.0, a Graduate Record Examination (GRE) minimum score (verbal + quantitative) of 1200, three letters of recommendation, and a personal statement of educational goals are required to be considered for admission into the Ph.D. program. For international students, a TOEFL score of at least 550 is also required. For applicants without a chemical engineering degree, the Department Graduate Coordinator will determine a plan of study that will facilitate successful completion of all requirements for the Ph.D. degree. This may include additional coursework, independent study, or other means to enhance the student's knowledge of key elements in this field.

Degree Requirements

1. Credit Hour Requirements

Ph.D. candidates must complete a minimum of 70 credit hours of coursework beyond the bachelor's degree. The Lamar University Chemical Engineering Ph.D. program requires a coherent program of (1) 15 credit hours selected from the specified core courses, (2) 21 credit hours of elective courses in chemical engineering or related fields (electives from other colleges must be approved on a case-by-case basis), (3) 4 hours of Professional Seminar (ENGR 6110), (4) a research project of at least 12 hours of research courses (CHEN 6680 for regular semester; CHEN 6380 for summer) prior to admission to candidacy, and (5) 18 hours of Ph.D. dissertation courses (CHEN 6690 and CHEN 6691 for regular semester; CHEN 6390 and CHEN 6391 for summer) after admission to candidacy.

2. Direct Action Items

- **Ph.D. Advisor and Advisory Committee**

The Ph.D. advisor is mutually selected by the student and the faculty member. The Ph.D. advisor must be a Lamar University graduate faculty member in the Department of Chemical Engineering. The Ph.D. Advisory Committee will consist of a minimum of three Lamar University graduate faculty members in the Department of Chemical Engineering

and one graduate faculty member from another department or one qualified expert from other institutions, organizations, or industry with the invitation of the advisor and the approval of the Department Chair, the Dean of Engineering, and the Dean of Graduate Studies. In addition, the Dean of Graduate Studies will appoint a graduate faculty member from another college as the Graduate Council Representative at both the defense of the dissertation proposal and the oral defense of the dissertation.

• **Written Qualifying Examination**

Each student desiring the Ph.D. degree is required to pass a written qualifying examination. The purpose of the written qualifying examination is to test the student's understanding of basic scientific and engineering principles and their application to the student's research interests. Students must attempt the written qualifying examination during either their second or third long semester in the program. The written qualifying examination is administered once each long semester. The student's cumulative graduate GPA must be at least 3.0 at the time of the examination.

The written qualifying examination is an eight-hour written examination with a selection of problems from Transport Phenomena, Thermodynamics, Kinetics and Engineering Mathematics designed to test understanding of basic concepts and principles. Based on the results of the written qualifying examination, the Ph.D. qualifying examination committee will recommend the student (1) be allowed to prepare a dissertation proposal, (2) be granted a second and final attempt at one or more parts of the examination, or (3) be withdrawn from the Ph.D. program.

• **Degree Plan**

Students must select their Ph.D. advisor within one semester after passing the Ph.D. written qualifying examination. Students must submit their degree plans within one year of passing the Ph.D. written qualifying examination. The degree plan must be approved by the Ph.D. advisor, the Department Graduate Coordinator, the Department Chair, the Dean of Engineering, and the Dean of Graduate Studies.

• **Dissertation Proposal**

The general field of dissertation research should be agreed upon by the student and the Ph.D. Advisory Committee. As soon thereafter as the research project can be outlined in reasonable detail, the student should complete the dissertation proposal. The dissertation proposal must be approved at a meeting of the student's Advisory Committee. The committee will also review the feasibility of the proposed research and the adequacy of available facilities.

The approved proposal must be signed by all members of the student's Advisory Committee (with the exception of the Graduate Council Representative), the Department Chair, and the Dean of Engineering. It must be submitted to the College of Graduate Studies at least 14 weeks prior to the scheduling of the final examination.

Students performing research involving human subjects, animals, infectious biohazards or recombinant DNA must receive approval from the College of Graduate Studies prior to conducting their research.

The student is admitted to candidacy only after the defense and the approval of the dissertation proposal and the completion of a minimum of 12 graduate credit hours.

• Dissertation Preparation

After the dissertation proposal is approved, the candidate may begin to prepare the dissertation under the guidance of the Ph.D. advisor and the Advisory Committee. The dissertation must be an original work of the candidate that demonstrates the student's ability to perform independent research. Acceptance of the dissertation is based primarily on its scholarly merit, but it must also exhibit credible literary workmanship. The format of the dissertation must be acceptable to the College of Graduate Studies.

The candidate must submit a single, unbound copy of the dissertation in final form to the College of Graduate Studies at least 10 days before the oral dissertation defense (final exam).

• Dissertation Defense

The candidate for the Ph.D. degree must pass a dissertation defense by deadline dates announced in the Academic Calendar each semester or summer term. No student may defend a dissertation without having current official cumulative and degree plan GPAs of 3.0 or better and without having been admitted to candidacy. There must be no grades of D, F, I, or U for any course listed on the degree plan. To absolve a deficient grade, a student must repeat the course and achieve a grade of C (or S) or better. Students must be registered during the semester in which the dissertation defense takes place and must have completed all course work on their degree plans with the exception of remaining dissertation courses.

The qualifying examination results and the dissertation proposal must be submitted to the College of Graduate Studies at least 14 weeks prior to the date of the defense. The request for permission to hold and announce the dissertation defense must be submitted to the College of Graduate Studies a minimum of 10 working days in advance of the scheduled defense date. The dissertation defense for the Ph.D. degree must be administered on campus unless otherwise authorized by the College of Graduate Studies.

The student's Ph.D. Advisory Committee, as finally constituted, will evaluate this dissertation defense. A positive vote by members of the Ph.D. Advisory Committee (with the exception of the Graduate Council Representative) with no more than one dissension is required to pass the defense. The candidate and all visitors must excuse themselves from the proceedings before the vote.

The Advisory Committee will submit its recommendations on the appropriate form to the College of Graduate Studies regarding acceptability of the candidate for the Ph.D. degree. Defenses that are not completed and reported as satisfactory to the College of Graduate Studies within 2 working days of the scheduled defense date will be recorded as failures.

By dates announced each semester in the Academic Calendar, the candidate must submit to the College of Graduate Studies three official copies of the dissertation in final form on rag content paper with two extra copies of the abstract. The dissertation must include all suggestions and corrections of the members of the student's Advisory Committee and must bear the signatures of the advisor, the Department Chair, the Dean of Engineering, and the members of the student's Advisory Committee, with the exception of the Graduate Council Representative.

3. Special Conditions

• **Transfer of Credits**

Courses for which transfer credits are sought must have been completed with a grade of A, B, or S (Satisfactory) and have been accepted as graduate credits by an accredited institution where the work was taken. Transfer credits must be approved by the student's advisor, the Department Graduate Coordinator, the Department Chair, and the College of Graduate Studies. For students with a master's degree from another accredited institution, only the graduate level courses taken during their study for a master's degree and pertaining to the field of current study can be transferred. For students without a master's degree, a maximum of 6 hours may be transferred. Students may transfer a maximum of 6 hours of Ph.D. courses beyond the credits used for the master's degree.

• **Residence**

Students who enter the Ph.D. degree program with only a baccalaureate degree must spend at least two academic years in resident study. Students holding master's degrees upon entering the Ph.D. degree program must spend at least one academic year in resident study. One academic year may include two adjacent long semesters or one long semester and two adjacent six-week summer semesters.

• **Continuous Enrollment Requirement**

From the time they advance to candidacy until the defense of their dissertation, Ph.D. students must maintain continuous enrollment by registering for at least six credit hours each long semester until the dissertation is approved and accepted. Special cases must be approved by the advisor, the Department Graduate Coordinator, the Department Chair, the Dean of Engineering, and the Dean of Graduate Studies.

• **Time Limit**

All requirements for the Ph.D. degree must be completed within a period of ten consecutive calendar years for the degree to be granted. A course will be considered valid until 10 years after the end of the semester in which it is taken. Graduate credit for course work more than ten calendar years old at the time of the final oral examination may not be used to satisfy degree requirements.

Final corrected copies of the dissertation and record of study must be accepted by the College of Graduate Studies no later than one year after the dissertation defense or within the 10-year time limit, whichever occurs first. Failure to do so will result in the degree not being awarded.

Core Courses

CHEN 5302 Transport Phenomena
CHEN 5352 Advanced Process Control
CHEN 6343 Kinetics and Reactor Design
CHEN 6345 Fundamentals of Sustainability
CHEN 6347 Advanced Thermodynamics
CHEN 6348 Advanced Chemical Engineering Mathematics

Core Courses (15 Credit Hours)

CHEN 5302 Transport Phenomena
Analysis of transport with respect to fluid dynamics, heat arid mass transfer. Derivation of Navier-Stokes Equation and its application to flow phenomena. Boundary layer flows, molecular interpretation of viscosity, and interfacial tension and Its relation to slip/non-slip condition. Interdependence of fluid flow, heat transfer, and mass transfer. Tensor and vector notation will be presented and employed.

CHEN 5352 Advanced Process Control
Modem control theory concerning state-space formulation, multivariable control, optimal control, and discrete control for Jumped/distributed parameter systems is addressed. Applications of control theory and the implementation of control strategies for the chemical processing industries are demonstrated

CHEN 6343 Kinetics and Reactor Design
Emphasis is placed on complex reactor design, Attention is devoted to chemical kinetics and catalysis as *well as* to the engineering aspects of both homogeneous and heterogeneous reactors. Mixing problems in terms of residence, time distribution. The importance of temperature effects is stressed.

CHEN 6345 Fundamentals of Sustainibility
This course examines the scientific basis and technology details of sustainability, defined as "minimization of the effect of entropy on society," Emphasizes the interface among engineering, environment, and economics. Incorporates the ideas of sustainability into chemical engineering fields such as process and product design, manufacturing, and value chain management *for* the purpose of minimizing both *resource* utilization and adverse environmental impact.

CHEN 6347 Advanced Thermodynamics
Derivation of thermodynamic laws and application to physical chemical phenomena. Development of ideal and non-ideal gas, liquid, and solid solution behaviors for physical and chemical equilibria. Course credit in chemistry is optional.

CHEN 6348 Advanced Chemical Engineering Mathematics
The course covers the fundamentals and numerical techniques for Linear Systems of Equations, Nonlinear Systems of Equations, Numerical Differentiation/Integration, Regression Analysis, Systems of Ordinary Differential Equations, and Partial Differential Equations, for modeling and analysis of chemical engineering systems.

Graduate Faculty

Associate Professor Kendrick (Ken) Aung
Combustion, propulsion, energy systems, sprays, mixing
Professor Wendell C. Bean
Control systems, biomedical signal processing
Assistant Professor Mark Bourland
Mechanics, structural, bridge design
Professor Daniel H. Chen
Process control, process simulation, air pollution control
Professor Hsing-wei Chu
Operations research statistical decision analysis, networks
Professor David L. Cocke
Analytical and environmental chemistry, catalysis
Professor Paul Corder
Mechanical systems design; stress analysis; finite element models
Associate Professor Brian N. Craig
Ergonomics, human factors, safety
Assistant Professor James Curry
Operations research, supply chain optimization, simulation
Associate Professor John L. Gossage
Reaction kinetics, reactor design, polymerization
Professor Tho-Ching Ho
Fluidization, heat transfer, optimization
Professor Jack R. Hopper
Reaction kinetics, catalysis, pollution prevention
Associate Professor Mien Jao
Geotechnical engineering
Professor Enno Koehn
Construction, planning, scheduling and productivity, design and analysis
Professor Ku-Yen Li
Mass transfer, gas-liquid reactions, unit operations in environmental engineering
Assistant Professor Xianchang Li
Heat transfer, energy conservation, thermal systems, turbomachinery, numerical simulation
Associate Professor CheJen (Jerry) Lin
Environmental engineering
Assistant Professor Sidney Lin
Materials science, fuel cells, ceramic membrane separation
Assistant Professor Xinyu Liu
Micro-manufacturing, statistical quality control CAD/CAE/CAM
Associate Professor Helen Lou
Process modeling, simulation and optimization; Sustainable Engineering
Assistant Professor Alberto Marquez
Scheduling, supply chain optimization, financial engineering
Professor Harley R. Myler
Image and signal processing, digital video, video communications and networks, control systems
Associate Professor G.N. Reddy
Computer engineering, artificial neural networks & fuzzy logic, digital signal processing, Industrial automation, Instrumentation, Virtual systems, Computer networks
Assistant Professor Selahattin Sayil
VLSI design and testing, contactless testing and testability, interconnect noise modeling, cmac neural networks
Professor Malur Srinivasan
Advanced materials processing, modeling of microstructure evolution in manufactured products, development of nanostructured engineering products
Assistant Professor Rafael Tadmor
Wetting/Dewetting phenomena, forces between surfaces, viseosity of confined liquids, biolubrication forces in biological systems
Associate Professor Ryan Underdown
Enterprise Engineering
Engineering Management
Assistant Professor Bin Wang
Molecular self-assembly, mass tranfer of ultrathin films, nanoparticulate electrochemical catalysts

Graduate Faculty (con't)

Associate Professor Ruhai Wang
Computer Networks, Internetworking, Telecommunication systems, Microcomputer and computer architecture

Assistant Professor Qiang Xu
Sustainable Systems Engineering and Industrial Sustainability; Process and Product Synthesis and Integration

Professor Carl L. Yaws
Physical and thermodynamic properties, distillation

Professor Fred M. Young
Fluid dynamics, heat transfer

Professor Robert Yuan
Structural Analysis, Experimental Mechanics, Civil Engineering Composites

Professor Victor Zaloom
Engineering economics, manufacturing productivity, computer applications, statistical quality control

Assistant Professor Jiang (Jenny) Zhou
System dynamics, system optimizations, mechanical issues in microelectronics, biomechanics

Assistant Professor Weihang Zhu
Computer haptics, virtual reality, computer aided design and manufacturing/computer numurial control, medical simulation, computational geometry, information technology

Engineering Courses (ENGR)

5101, 5201, 5301 Special Topics **3:1-3:0**
An investigation into specialized study in advanced areas of engineering under guidance of a faculty member. This course may be repeated for credit when topics of investigation differ.

5110 Seminar **1:1:0**
Discussion of ethical, professional, and technical topics related to the practice of civil engineering. Presentation of oral and written reports.

5306 ENGR Internship – 1 **1:1:0**
Internship opportunity provides experience in the practice of engineering for graduate students. Its purpose is engineering career development.

5307 ENGR Internship – 2 **1:1:0**
Internship opportunity provides experience in the practice of engineering for graduate students. Its purpose is engineering career development.

5311 Heat Transfer Analysis **3:3:0**
Fundamental principles of heat transfer by conduction, convection and radiation. Emphasis will be given to the analysis of problems combining the various heat transfer mechanisms.

5348 Advanced Air Pollution Control **3:3:0**
Air pollution control and design principles; VOC incineration; gas absorption; air pollution and atmospheric dispersion modeling; particulate matter; cyclones, electrostatic precipitators; fabric filters and scrubbers; control of nitrogen oxides and sulfur oxides.

5390-5391 Thesis **6:A:0**
Prerequisite: Approval of graduate advisor. Must complete both for required 6 credits.

6110 Professional Seminar **1:1:0**
Advanced topics suitable for research along with research procedures will be discussed. Field study organization and content together with doctoral research problems and progress will be presented. Topics will vary each semester and course may be repeated for credit. Registration and completion for three semesters is required of all doctoral candidates.

6310 Design Projects **3:A:0**
May be repeated for credit when the subject matter varies.
Prerequisite: Admission to candidacy.

6320 Justification of Engineering Projects **3:3:0**
The preparation of proposals for advanced engineering work. The student will be given individual assistance in preparing a proposal for his field study.
Prerequisite: Approval of advisory committee.

6349 Engineering Applications of AI/Expert Systems **3:3:0**
An in-depth study of the effective utilization of Artificial Intelligence/Expert Systems as applied to engineering problems. Projects assigned will involve the design and development of software systems to solve discipline-specific problems using available AI languages and expert system shells.

6369 Computer Methods of Engineering Optimization **3:3:0**
Formulation, solution and implementation of optimization models such as linear programming, dynamic programming, integer programming, quadratic programming, convex programming, geometric programming and unconstrained optimization for analyzing complex systems problems in industry. One or more software packages will be used to execute the algorithms presented throughout the course.
Prerequisite: A graduate course in operations research.

6389 Computer-Aided Software Engineering **3:3:0**
Analysis and utilization of computer software to solve engineering design problems. Applications on the CAD/CAE and various other systems will be emphasized.

6601 Engineering Practice **6:A:0**
An internship period under personal supervision. Approval must be obtained from the student's graduate committee. Usually, a formal proposal will be required. May be taken for either six or 12 hours credit per semester. Must be repeated for credit until field study is completed. Total credit: six semester hours per section.

6602 Engineering Practice **6:A:0**
An internship period under personal supervision. Approval must be obtained from the student's graduate committee. Usually, a formal proposal will be required. May be taken for either six or 12 hours credit per semester. Must be repeated for credit until field study is completed. Total credit: six semester hours per section.

Chemical Engineering Courses (CHEN)

5302 Transport Phenomena **3:3:0**
Analysis of transport with respect to fluid dynamics, heat and mass transfer. Derivation of Navier Stokes Equation and its application to flow phenomena. Boundary layer flows, molecular interpretation of viscosity, and interfacial tension and its relation to slip/non slip condition. Interdependence of fluid flow, heat transfer, and mass transfer. Tensor and vector notation will be presented and employed.

5341 Mass-Transfer Operations **3:3:0**
The principles of diffusion and mass transfer are considered. The study of gas-liquid operations includes humidification and design of equipment. Solid-fluid studies include absorption, ion exchange, drying and leaching operations. Less conventional mass-transfer operations are also considered.

5342 Reactor Design for Environmental Systems **3:3:0**
Development of the fundamentals for the rate of chemical reactions and biological reactions in homogeneous and heterogeneous systems. Analysis of ideal chemical reactors and their design with application to environmental reactions in the air, water and soil. An introduction to the basic concepts of mathematics modeling. The subject matter is directed toward chemical and petroleum engineering design and operation. Development of models which form the framework of a quantitative and scientific approach to technical problems will be followed by analytical and/or numerical solutions to optimize output and profitability.

5352 Advanced Process Control **3:3:0**
Modem control theory concerning state space formulation, multivariable control, optimal control, and discrete control for lumped/distributed parameter systems is addressed. Applications of control theory and the implementation of control strategies for the chemical processing industries are demonstrated.

5357 Process Simulation
Steady state chemical and refining processes simulation using state-of-the-art computer software.

5358 Advanced Process Simulation
In depth coverage of chemical and refining processes using state-of-the-art steady-state computer simulation software. Advanced topics and fundamentals are emphasized.

5359 Dynamic Simulation
Chemical and refining process dynamic simulation using state-of-the-art computer software. Controller installation and central schemes are discussed.

5360 Thermodynamics-Process Industry **3:3:0**
Thermodynamic laws are derived and applied to physical chemical phenomena. Ideal and non-ideal gas, liquid and solid solution behavior are developed for physical and chemical equilibria. Course credit in chemistry is optional. May be repeated one time for graduate credit, with prior approval, where course content varies.

5361 Process Optimization **3:3:0**
Linear and non-linear optimization. Introduction to optimization technique and concepts.

5371 GIS in Water Resources **3:3:0**
Introduction or geographic information system (GIS-ArcView or Arc/Info) to analyze spatial data for engineering feasibility study. Discussion of application of GIS in water resource engineering (digital elevation models, river and watershed networks, and land use mapping, hydrological modeling). May be repeated for credit when subject matter varies.

5392 Intermolecular Forces with Applications to Biology **3:3:0**
An introduction to the various intermolecular and inter-particle interactions in solutions and in colloidal systems: van der Waals, electrostatic, hydrophobic. Polymers in solutions, surfactants in solutions, colloidal systems in electrolyte environment, with surfactants and with polymers. Surfaces and interfaces: surface energy, surface tension, wetting, biological surfaces and cell membranes, and how polymers interact with cell membrane.

5394 Wetting Phenomena and Transport Related Effects **3:3:0**
Young-Dupre approach to wetting and the relation between Marangoni Effect and the spreading coefficient. Covers the concept of complete wetting, partial wetting, and non-wetting systems. Follows some experimental methods related to wetting.

6110 Professional Seminar **1:1:0**
Advanced topics for research procedures, field study organization and content, Ph.D. research problems and progress. Topics vary each semester. Registration and completion for four semesters is required for all Ph.D. candidates. *May be repeated for credit.*

6340 Distillation **3:3:0**
Material and energy-balance relationships are reviewed for multicomponent fractionation equipment and for batch stills. Various plate designs are presented from the standpoint of two-phase hydraulics and mass-transfer efficiency.

6343 Kinetics and Reactor Design **3:3:0**
Emphasis is placed on complex reactor design. Attention is devoted to chemical kinetics and catalysis as well as to the engineering aspects of both homogeneous and heterogeneous reactors. Mixing problems in terms of residence time distribution. The importance of temperature effects is stressed.

6344 Multimedia Transport of Pollutants **3:3:0**
Chemical transfer rates between air and water, water and soil/sediment, as well as air and soil. Intraphase pollutant processes in atmosphere, surface water, and ground water. Description of the dispersion model and the meterological effects on pollutant transport. Discussion of partition to biomass and exposure pathways.

6345 Fundamentals of Sustainability **3:3:0**
This course examines the scientific basis and technology details of sustainability, defined as "minimization of the effect of entropy on society." Emphasizes the interface among engineering, environment, and economics. Incorporates the ideas of sustainability into chemical engineering fields such as process and product design, manufacturing, and value chain management for the purpose of minimizing both resource utilization and adverse environmental impact.

6346 Sustainability Applications **3:3:0**
Practical applications of sustainability to topics including environmental research, pollution prevention, plant safety/abnormality management and control, process optimization, renewal energy, innovative material, and biotechnology to support the sustainability of our environment, society, and industry.
Prerequisite: Fundamentals of Sustainability (CHEN 6345).

6347 Advanced Thermodynamics **3:3:0**
Derivation of thermodynamic laws and application to physical chemical phenomena. Development of ideal and non ideal gas, liquid, and solid solution behaviors for physical and chemical equilibria. Course credit in chemistry is optional.

6348 Advanced Chemical Engineering Mathematics **3:3:0**
The course covers the fundamentals and numerical techniques for Linear Systems of Equations, Nonlinear Systems of Equations, Numerical Differentiation/Integration, Regression Analysis, Systems of Ordinary Differential Equations, and Partial Differential Equations, for modeling and analysis of chemical engineering systems.

6368 Artificial Neural Networks & Fuzzy Logic 3:3:0
Study of various Artificial Neural Network architectures for real-world applications. Massive parallel computation, fault tolerance and adaptation characteristics. Emphasis on computer simulation of ANN-architectures and their applications.

6680 Research 6:A:0
A Ph.D. student must enroll in at least 12 hours of research courses (CHEN 6680) for conducting research project prior to admission to candidacy.

6690–6691 Ph.D. Dissertation 6:A:0
Continuous enrollment for at least six dissertation credit hours each semester upon advancement to candidacy. Direct supervised research. Graded on a credit (CR) or no credit (F) basis. Award of credit for the final dissertation course is contingent upon successful defense of the dissertation. Minimum of 18 credit hours is required.
Prerequisite: Admission to candidacy and approval of thesis advisor. 6690 must be taken once, followed by 6691 each semester until dissertation is completed.

Civil Engineering Courses (CVEN)

5212 Civil Engineering Systems Design Project 2:0:6
Planning, design, and analysis of a civil engineering system or project; an integrated and realistic group project is utilized which involves numerous major aspects of the civil engineering profession. Presentation of oral and written design reports.

5300 Advanced Structural Analysis 3:3:0
Review for methods of statically indeterminate structural analysis including constant deformation, slope deflection and moment distribution; introduction of stiffness and flexibility methods using matrix algebra, theories of arches, cables, cylindrical structures using classical and energy methods. May be repeated for credit when topics vary.

5308 Cost Optimization and Scheduling Engineering 3:3:0
Includes the mathematics of cost comparisons, profitability, productivity, and optimization with emphasis on engineering project scheduling, cost estimation, and control. May be repeated for credit when the subject matter varies.

5310 Advanced Concrete Design 3:3:0
Analysis and design of concrete members based upon working stress and strength design methods. Consideration given to pre-stressing or post-stressing of beams and structural components. May be repeated for credit when the subject matter varies.

5313 Fluid Mechanics 3:3:0
Fluid statics, fundamentals of fluid motion, systems and control volumes, basic laws, irrotational flow, similitude and dimensional analysis, incompressible viscous flow, boundary layer theory and an introduction to compressible flow. Vector methods will be employed.

5314 Hydraulic Engineering 3:3:0
Design considerations of hydraulic systems including closed and open channel flow together with related hydraulic accessories. May be repeated for credit when the subject matter varies.

5317 Materials Engineering Analysis/Laboratory 3:2:3
The nature and properties of materials used in civil engineering such as structural metals, concrete, timber, composites and bituminous materials. The engineering application and performance of materials are emphasized. Various properties and behavior of engineering materials are investigated by laboratory experimentation.

5318 Stress Analysis and Material Systems 3:3:0
A study of solid mechanics and/or building/hydraulic systems related to the performance of different materials such as soils, metals, timber, masonry, and composites under various loading conditions. Consideration of construction and environmental effects. Topics may include, if applicable, unsymmetrical sections, shear center, curved beams, torsion of noncircular cross sections, strain energy, virtual work, plasticity, fatigue, and introduction to the theory of elasticity. May be repeated for credit.

5320 Engineering Project Management 3:3:0
Principles governing the effective and efficient management of engineering projects including the application of comprehensive planning, scheduling, and cost estimation procedures. Presentation of oral and written design reports.

5323 Advanced Steel Design 3:3:0
Analysis and design of structural members using steel. Consideration is given to elastic and inelastic buckling in beams and columns due to local, flexural, torsional and torsional flexural action. May be repeated for credit when the subject matter varies.

5324 Models In Hydrological Systems
Analysis of basin hydrology, steamflow frequency, and water surface profiles, introduction to wave machines and hydrological transport processes including water quality simulation in hydrodynamic systems (oceans, estuaries, lakes/reservoirs, rivers/streams, storm water control facilities). May be repeated for credit when subject matter varies.

5325 Fundamentals of Air Pollution 3:3:0
Pollutant sources, emissions and transport. Air pollution control methods. Particulate collection theory, gaseous pollutant removal theory. Atmospheric sampling and analysis methods. May be repeated for credit when the subject matter varies.

5326 Hydrologic and Hydrodynamic Processes 3:3:0
Overview of hydrological models, hydrological design and hydrodynamic processes in bodies of water (rivers/streams, oceans, estuaries, inland lakes, and reservoirs); energy and momentum transfer through a water surface; standing or progressive waves; salt water and fresh water interaction; wind effects of stratification and circulations; analysis of stratified flow and density currents; selective withdrawal; turbulent wind mixing. Consideration of environmental effects. May be repeated for credit when the subject matter varies.

5327 Numerical and Computer Methods In Structures 3:3:0
Matrix and computer methods applied to analysis and design of trusses, beams, and frames. Consideration of CAD techniques. May be repeated for credit when subject matter varies.

5328 Theory of Structures 3:3:0
Investigation and design of facilities under static, hydraulic, dynamic, and/or hazardous loading conditions. Principles of ultimate strength and plastic design theories. Consideration of environmental effects and safety factors for various temporary and/or permanent loading situations. May be repeated for credit when the subject matter varies.

5329 Water Supply and Treatment 3:3:0
An investigation of the chemistry of water treatment processes including the study of treatment process selection and associated design parameters.

5331 Biological Wastewater Treatment 3:3:0
Principles of treatment for domestic and industrial wastewaters with emphasis on process kinetics and biological action.

5332 Introduction in Composite Structures 3:3:0
Mechanics and technology of composite materials and applications of composites in structures. Structure-properties dependencies and design of composite materials. Stress and strength analysis and optimization for typical composite structures. Beams, plates and shells made from composites. Mechanics of effectively anisotropic bodies.

5338 Solid Waste Management 3:3:0
A study of solid waste collection, transfer and disposal systems. Investigation of the reclamation of resources by multiple use, reuse and improvement of existing sources to meet quality requirements.

5340 Foundation Engineering 3:2:3
The practice of geotechnical engineering: subsurface explorations; geotechnical analysis and design of shallow footings, deep foundations, and retaining structures; stability of earth slopes, and soil improvement.

5343 Industrial Waste Treatment 3:3:0
Procedures for analysis of the industrial waste problem, methods of collecting experimental data and process design for required treatment. Case studies and special laboratory problems for translating experimental data to prototype design. May be repeated for credit when the subject matter varies.

5347 Statistical Principles in Engineering Systems
Review of engineering data types and its treatment/presentation for inferences. Specific topics include: descriptive statistics, probability density functions, sampling distribution, hypothesis test, confidence interval, linear and curvilinear regressions, analysis of variance, design of experiment and statistical quality control. Examples of the application of statistics in civil and environmental engineering will be emphasized.

5350 Hydraulic Engineering Systems 3:2:3
Continuation of CVEN 3350Hydraulics I emphasizing practical design applications of basic fluid mechanics principles in fluid measurement, machinery, closed conduit flow, open channel flow and hydraulic transients. Presentation of oral and written design reports.

5351 Unit Operations of Environmental Engineering 3:3:0
Theory of fluid and slurry movement under gravity and pressure systems, mixing processes, coagulation and flocculation of chemical treatment, separatory processes including flotation and sedimentation, and gas transfer and absorption of the biological systems. Selected laboratory assignments for model studies of these unit operations.

5355 Advanced Geotechnical Engineering 3:3:0
Evaluation of strength parameters and compressibility of soils, elastic analysis of the stress and strain, techniques of forecasting foundation settlement, and slope stability analysis.

5381 Building Design/Construction **3:3:0**
Advanced topics in Building and/or Construction Systems. Topics may include the treatment of contaminated soils, and the effects of various static, dynamic, hydraulic, and wind loads on structural frames and foundations. Environmental, social, and safety requirements may be taken under consideration. Presentation of oral and written design reports. May be repeated for credit when topics vary.

5387 Special Topics **3:3:0**
The course is designed to meet special needs of students. Each topic is offered on an irregular schedule as the demand requires. Sample topics include: (1) Kinetic theory of gases; (2) Transients in compressible flow; (3) Nonlinear vibrations; (4) Protective construction; (5) Transients in engineering systems; (6) Stagewise mass transfer; (7) Nuclear engineering; (8) Hybrid and analog computers; (9) Adaptive control; (10) Optimization techniques; (11) Sampling techniques.

5388 Special Topics **3:3:0**
The course is designed to meet special needs of students. Each topic is offered on an irregular schedule as the demand requires. Sample topics include: (1) Kinetic theory of gases; (2) Transients in compressible flow; (3) Nonlinear vibrations; (4) Protective construction; (5) Transients in engineering systems; (6) Stagewise mass transfer; (7) Nuclear engineering; (8) Hybrid and analog computers (9) Adaptive control; (10) Optimization techniques; (11) Sampling techniques.

5398 Reinforced Concrete Design **3:2:3**
The design of structural concrete members based upon working stress and strength design methods. Study of standard specifications. Introduction to prestressed concrete.

5399 Structural Steel Design **3:2:3**
The design of buildings and bridge components according to standard specifications. Application of load and resistance factor and allowable stress design methods. Introduction to plastic design of steel structures.

6330 Air Quality Modeling **3:3:0**
Review of various air quality models. Introduction and implementation of air quality science in model simulation including the emission inventory, dynamic meteorology and chemical transport. Air quality simulation using first principle models will be emphasized.

6332 Advanced Foundation Engineering **3:3:0**
Investigate practical applications of soil mechanics principals to geotechnical engineering, dewatering techniques, design and analysis of deep foundations and retaining structures.

6333 Chemical Principles of Envirorunental Systems **3:3:0**
Introduction to aquatic and atmospheric chemistry, chemical kinetics and equilibrium, acid-base chemistry, chemical buffer, metal-ligand chemistry, precipitation and dissolution, redox chemistry and radical chemistry.

6336 Stormwater Management and Design **3:3:0**
Introduction of stormwater quality and quantity management and simulation models (e.g., SWMM, StormCAD), introduction to the Best Management Practice and Total Maximum Daily Load for coastal areas, and design of urban stormwater system facilities, e.g., detention ponds, culverts, channel system and stormwater pipes.

6339 Hazardous Waste Management **3:3:0**
The design, operation and applicability of standard destruction and detoxification technologies will be presented. The various types of incineration, thermal, biological, physical and chemical treatment methods will be included, as well as the technologies now in the later stages of research and development. Emphasis will be on applicability and functional design as opposed to detailed design.

6345 Water Quality Modeling and Monitoring **3:3:0**
Introduction to water quality simulation in natural water systems, e.g., water temperate, dissolved oxygen model in lakes/reservoirs/estuaries, turbulent diffusion and dispersion in one and two dimensional systems, and chemical and biological kinetics in water quality model. Introduction to monitoring of air and water quality parameters in coastal areas, including solids, dissolved oxygen, BOD, COD, salinity, criterion pollutants and selected instrumental analysis.

6387 Hydraulics of Environmental Systems **3:3:0**
Hydraulic design of municipal utilities including storm water and waste water collections systems, water distribution networks and treatment plant facilities.

6388 Computer Methods of Engineering Project Management **3:3:0**
Principles governing the effective and efficient management of engineering projects including the application of comprehensive planning, scheduling and cost estimation procedures. Utilization of various computer methods and systems will be emphasized.

Electrical Engineering Courses (ELEN)

5344 Electric Power Systems Analysis I **3:3:0**
A three-semester sequence, selected from: symmetrical components, impedance and fault-current calculations, load-flow studies, economic operation, stability and control, system modeling, non-fossil fuel energy conversion. Both analytical and digital-computer methods may be employed as appropriate.

5346 Digital Signal Processing **3:3:0**
Sampling/reconstruction, quantization, discrete-time systems, digital filtering, Z-transforms, transfer functions, digital filter realizations, discrete Fourier transform (DFT) and fast Fourier transform (FFT), finite impulse response (FIR) and infinite impulse response (IIR) filter design, and digital signal processing (DSP) applications.

5354 Discrete Control Systems **3:3:0**
Principles of digital and sampled-data control systems. Analysis of response, and stability. Analytical compensation by Z-transform and other methods. Extensive use of computers.

5362 Remote Sensing **3:2:3**
Design of systems which gather and share data over geographically scattered remote locations. Real-time access, monitoring, diagnosis, and control of remote locations. Communication systems design using radio-telemetry, satellite, and dial-up networks. Data interface to the Internet. Information sharing through dynamic-web site design.

5365 Image Processing I
Twodimensional signal processing techniques; pictorial image representation; spatial filtering; image enhancement and encoding; segmentation and feature extraction; introduction to image understanding techniques.

5373 Advanced Electromagnetics **3:3:0**
Graduate-level topics in electromagnetic theory and applications. Assumes a grounding in electromagnetic fields and waves and methods for the solution of boundary value problems.
Prerequisite: ELEN 3371 or equivalent.

5383 Instrumentation **3:3:0**
Unified methods for the design of signal conditioning circuits between sensors and computers. Accepted practice for sensor-based microprocessor and microcomputer data acquisition and processing systems instrumentation amplifier circuits.

5384 Virtual Systems Design **3:2:3**
Design of virtual systems that replace complex hardware systems such as measurement systems, analyzers, and controllers. Object-oriented-programming (OOP) techniques that realize true representations of hardware. Design of Windows engineering applications.

5393 Introduction to VLSI Design **3:3:0**
Study of the principles of basic microchip design. Use of several CAD tools, with hands-on experience in implementing Very Large Scale Integration (VLSI) circuits. Detailed study and computer simulation of MOS-capacitance models.

5395 Computer Hardware Description Languages **3:3:0**
A CAD method of design of digital hardware using Computer Hardware Description Languages (CHDLs). Implementation of combinational logic units, microprocessors and microprogrammed processors.

5397 Fault Diagnosis & Fault Tolerant Design **3:3:0**
Study of several test generation algorithms for combinational circuits such as Boolean Difference, D, PODEM, and FAN Algorithms. Test generation techniques for RAMS and microprocessors. Various methods for Design for testability and Fault Tolerant Design.

6313 Digital Filters **3:3:0**
Introduction to digital filtering. Recursive, non-recursive filters and their design. Butterworth, chebysbev filters.
Prerequisite: Proficiency in computer programming.

6314 Computer Control and Instrumentation **3:3:0**
Basic Instrumentation principles. Signal acquisition and conditioning. Computer control using digital signal processing techniques in time and frequency domains. Programming project assignments involving implementation of basic instrumentation and computer control methods.

6358 Industrial Automation and Process Control **3:2:3**
Design and develop industrial automation and process control (IAPC) systems and processes. Distributed control system design, implementation of real-time process databases and man-machine interface. Study of modern techniques for process control and management. This is a graduate engineering Core course available to all engineering graduate students.

6365 Image Processing II **3:3:0**
Current topics in image processing research: nonlinear and adaptive filtering, color image processing, image encoding and digital video processing.

6374 Nonlinear Optics **3:2:3**
Advanced topics in Nonlinear Optics including a lab component. May be repeated for credit when subject matter varies.

6394 CAD Tools for VLSI Design **3:3:0**
Study of the principles involved in the development of a variety of Computer Aided Tools used in the design of Very Large Scale Integrated circuits. Implementation of the tools with programming assignments.

Industrial Engineering Courses (INEN)

5300 Quality Improvement **3:3:0**
Statistical methods and other Industrial Engineering analysis and design tools are used to control and improve quality and assure requirements are met. Prerequisite: INEN 3320

5301* Graduate Seminar **3:3:0**
This seminar provides a platform for the facilities, industry and students to communicate effectively regarding research opportunities and job opportunities.

5303 Regression Analysis **3:3:0**
Review of regression analysis; theory of least squares; multivariate analysis; theory of the general linear hypothesis model.

5305 Reliability **3:3:0**
Statistical theories pertinent to solution of engineering problems in reliability; distribution and failure theory including failure rate and mean time to failure for the exponential, log normal, gamma and Weibull distributions.

5315 Industrial Management **3:3:0**
Provides a foundation for becoming a manager in an industrial organization. Topics include: Strategic planning, culture change, organizational analysis and technology management. Students will apply decision making methodologies to hypothetical situations. Prerequisite: Graduate Standing.

5316 Industrial and Product Safety **3:3:0**
Convey an appreciation of the social and economic impact of industrial accidents. Provide general rules and checklist to help design and maintain a safe work place. Introduces the role of government and voluntary standards in process and product design safety. Prerequisite: Work Design

5319 Design of Experiments **3:3:0**
Experimental design and analysis of experiments are developed as tools of the manufacturing and process industries. Exploratory and evolutionary EVOP designs, analysis of variance ANOVA, error and regression are treated in some detail.
Prerequisite: Course in statistics or equivalent.

5320 Statistical Decision Making for Engineers **3:3:0**
Analysis of data to help the engineer/executive make decisions. Evaluations of performance claims, probability distributions, hypothesis testing, ANOV, design of experiments.

5333 Operations Research II **3:3:0**
Advanced topics in operations research-linear programming, non-linear programming, advanced topics in queuing and inventory theories, sensitivity analysis and dynamic programming.
Prerequisite: ENGR 5372 or equivalent.

5345 Computer Integrated Manufacturing (CIM) **3:3:0**
Advanced concepts in computer aided design and manufacturing to include geometric modeling in a 3D solids environment, analysis of engineering design problems, robotics, computer numerical control, and manufacturing control systems. Course includes a design project.

5350 Production and Inventory Control **3:3:0**
Techniques for planning and controlling production and inventories. Forecasting, aggregate planning, materials requirements planning, scheduling, project management.

5354 Lean Manufacturing **3:3:0**
The planning, evaluation, deployment and integration of lean manufacturing theory and methods. Emphasis on manufacturing processes/equipment and systems.
Prerequisite: INEN 3380.

5363 Six Sigma **3:3:0**
Overview of the six sigma DMAIC methodology at the green belt level of competency with emphasis on process management.
Prerequisite: INEN 3380.

5366 Advanced Engineering Economy **3:3:0**
Special economic analyses based on risk, uncertainty and other probabilistic considerations. Bayesian attacks, influence of perfect information, competitive decisions and decisions under pressure.

5369 Engineering Management **3:3:0**
Prepares students for a transition from engineering to management. Topics include: proposal writing, project negotiations, ethics, project management, teams and culture.

5370 Operations Research **3:3:0**
An introduction to the construction of mathematical models for organizational systems to aid executives in making decisions. Linear programming, network flow programming, dynamic programming, queuing theory.

5374 Human Factors Engineering **3:3:0**
Convey human factors considerations in design and research. Applications include control panels, audio and video displays, computer work stations, special accommodations.

5375 Simulation of I.E. Systems **3:3:0**
Introduction to concepts of simulation modeling and analysis with application to manufacturing and service systems. Students will apply problem solving and process analysis techniques to an industrial engineering problem and propose an improved systems design.
Prerequisite: Work Design, Probability and Statistics

5376 Occupational Ergonomics **3:3:0**
Application of ergonomics to the design and/or redesign of jobs, manufacturing workstations, and other work environments to achieve increased profitability and reductions in injury/illness.

5379 Facilities Design
Study of concepts and methods used to design an effective facility layout and materials handling system.

5381 Heuristic Algorithms
Heuristic Algorithms and applications to classical and real life problems. Justification and logic of heuristic algorithms. Greedy algorithms, Steepest Ascent, Numerical optimization, Simulated Annealing, Taboo Search, Cross entropy optimization, TSP, Set covering, Set partitioning.
Prerequisite: INEN 4370 or INEN 2360, or graduate students

5382* Data Mining
An introduction to data mining that covers data warehousing, data cleaning, data cubes, classification algorithms, clustering, and advanced regression techniques.
Prerequisite: None

5392 Virtual Reality and Haptics
This is introduction to virtual reality research course, which focuses on the emerging interdisciplinary field of virtual reality and haptic technology. Haptics is a research technology that will revolutionize all aspects of Information Technology as well as impacting in the general area of human machine interface design. The course will discuss the virtual reality architecture, the haptic (touch) software and hardware, and the virtual reality applications in design and manufacturing, medical simulation, education and training, etc.
Prerequisite: C/C++ programming required, Graphics programming experience preferred but not required (will cover the graphic basics in the course). A complementary course 'Computational Methods' is offered this semester to provide training on C++ programming and Computer Graphics.

5394 Engineering Database Design
To provide students in engineering with knowledge about the design and implementation of engineering applications using database technology. Examples will be drawn from manufacturing and production systems.
Prerequisite: It is assumed that students have had a programming course and are familiar with fundamental programming constructs. Visual Basic for Application is used in this course.

5395 Computational Methods
This course introduces students to numeric research. Major topics covered are C++, LP/IP software application development, and Computer Graphics.
Prerequisite: Any introductory programming course. Co-enrolled or completed an 'Operation Research' Course or 'Virtual Reality and Haptics' Course.

5396 Automated System Engineering
To provide students in engineering with knowledge about the industrial automation and process control in the manufacturing industry: control system, PLC, sensor and actuator, auto-id, flexible manufacturing system, assembly line and automatic inspection.

5385 I.E. Design **3:1:6**
Students design systems to solve a problem or problems typical of those encountered by practicing industrial engineers. Students work in teams to formulate issues, propose solutions, and communicate results in formal written and oral presentations.

** Pending approval by the Texas Higher Education Coordinating Board*

Mechanical Engineering Courses (MEEN)

5304* Advanced Engineering Analysis
The course covers selected topics of advanced engineering mathematics and their applications to engineering. The topics include analytical and numerical solutions of ordinary and partial differential equations, vector differential calculus and integral theorems, probability and statistics, and optimization.

5309 Problems in Design and Finite Analysis 3:3:0
Advanced techniques and analysis involving microcomputers, finite elements, finite differences. May be repeated for credit when the subject matter varies.

5311* Energy Conversion Systems 3:3:0
This course deals with different types of energy conversion devices and systems, including conventional heat engines, solar thermal systems, photovoltaic (PV), and future energy systems such as Stirling engines, microturbines, fuel cells, IGCC, and hydrogen-based energy systems. The course also introduces the theoretical background for direct energy conversion devices such as MHD, thermoelectric, and thermionic systems.

5315 Theory of Elasticity
General analysis of stress and strain, equations of equilibrium and compatibility, stress and strain relations, two dimensional stress problems, elastic energy principles, thermoelastic problems. May be repeated for credit when the subject matter varies.

5321* Applied Numerical Analysis 3:3:0
Introduction to numerical techniques and their applications in different engineering problems, experimental data analysis and statistical methods, optimization methods, and numerical methods in solving differential equations.

5322* Advanced Dynamics 3:3:0
Energy methods in dynamics, free and forced vibrations, applications to systems with one-, two-, and multi-degree of freedom, response to various excitations, transient response, engineering applications, and vibration in continuous systems.

5326* Control of Mechanical Systems 3:3:0
Mathematical modeling of various systems, transient and steady-state response, frequency response analysis, root-locus, stability, control system design, steady-sates representations, controllability and observability, and design of system in state space.

5333* IC Engines 3:3:0
This course deals with the theory, design, and simulation of internal combustion engines. The theory of internal combustion engines cover thermodynamic and fuel-air cycles, fuels and their properties, intake and exhaust flows, combustion and pollutant emissions, heat transfer, and modeling of IC engines. An IC engine simulation software will be used to solve practical IC engine problems. Current status and future challenges of IC engines will also be discussed.

5335 Mechanical Vibrations 3:3:0
Topics in mechanical vibrations including an introduction to the theory of vibrations, mechanical vibration analysis methods using simulationbased design, mechanical vibration measurement and monitoring, interpretation of vibration measurements data and other mechanical vibration topics as appropriate.

5356 Process Modeling with Neural Networks **3:3:0**
Multivariate Statistics, Genetic Algorithm, and empirical modeling tools such as Partial Least Squares, Monotonic/Bounded Derivative Neural Network, and Inferential Property Estimation using state-of-the-art computer software. These modeling tools take advantage of the large amount of process data now available in process plants for data mining.

5367* Intro to CFD **3:2:3**
Introduction to basic concepts underlying computational fluid dynamics (CFD) including derivation of governing equations, discretization methods, grid generation, solution algorithms, numerical solution methods, error prediction, and interpretation of numerical results. A commercial CFD software package, CFX, is use to solve practical engineering fluid flow problems.
Prerequisite: Fluid Mechanics, Heat Transfer, Numerical Methods, MEEN 5366.

5368* Combustion Theory **3:3:0**
Fundamental principals of combustion theory and their applications in different engineering problems such as furnaces, automotive engines, gas turbines, and rockets. Topics covered include thermochemistry, fuels, chemical kinetics, conservation equations for reacting flows, premixed and diffusion flames, droplet burning, and pollutant emissions, introduction to numerical modeling of combustion and combustion measurement techniques.
Prerequisite: Fluid Mechanics, Heat Transfer, Thermodynamics.

5369* Energy Conservation and Management **3:3:0**
Fundamentals of energy conservation and management, energy audit procedure and methodology, energy conservation analysis based on calculation of heat transfer, thermodynamics and economics, potential energy saving opportunities in different industrial areas, technologies to improve energy efficiency.
Prerequisite: Fluid Mechanics, Heat Transfer, Thermodynamics.

5370* Gas Turbine Heat Transfer & Cooling Technology **3:3:0**
The fundamentals of gas turbine heat transfer and cooling are introduced, including the effect of gas turbine cooling on its thermal performance. Different aspects of internal cooling and film cooling technologies are discussed. State-of-the-art experimental design and numerical modeling related to gas turbines heat transfer and cooling are presented.
Prerequisite: Fluid Mechanics, Heat Transfer.

5389 CAD **3:3:0**
Introduction to ProEngineer. The analysis and the utilization of state of the art computer hardware and software to solve the problems associated with the utilization of computers in both graphics and engineering design problems.
Prerequisite: Graduate standing in the College of Engineering and consent of the instructor.

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