



THE UNIVERSITY OF TEXAS AT SAN ANTONIO

Academic Policies and Procedures Handbook

Environmental Science and Engineering Ph.D. Program

October 2008

I. Ph.D. Program Areas of Study

The CEE department offers the opportunity for advanced study and research leading to the Doctor of Philosophy degree in Environmental Science and Engineering. This is a multidisciplinary program administered by the CEE Department. It encompasses faculty and facilities from the College of Sciences and the CEE Department, as well as individual faculty from other UTSA departments. Areas of research emphasis include water resources, environmental quality, environmental remediation, pollution control, conservation ecology, spatial analysis, remote sensing, and natural hazards. The Ph.D. degree in Environmental Science and Engineering is awarded to candidates who display an in-depth understanding of the subject matter and demonstrate the ability to make an original contribution to knowledge in their field of specialty.

II Governance

The Director of the ESE PhD Program is a faculty member in the CEE Department appointed by the Dean of the College of Engineering. The Director serves as the Graduate Advisor of Record (GAR) and the Chair of the Doctoral Studies Committee (DSC). The DSC consists of the Director and 4 faculty members, 2 from the College of Engineering and 2 from the College of Sciences. Half of these 4 faculty members are rotated every 2 years through elections amongst all the faculty members that participate in this joint program. The current DSC composition can be found under http://engineering.utsa.edu/CE/academics_phd_program.html. The DSC manages admissions, funding decisions, written qualifying examinations, curriculum development and course offerings and scheduling.

III. Admission Requirements

Specific Admission Requirements Applicants must satisfy the following requirements, in addition to satisfying the University-wide graduate admission requirements:

- a Bachelor of Arts or a Bachelor of Science degree and a Master of Science degree from an accredited university, and a minimum grade point average of 3.0 in upper-division and graduate courses. The degree should be in biology, ecology, environmental science, chemistry, geology, geography, engineering, or other related scientific discipline. Exceptional applicants without a Master of Science may be considered for admission to the program on a case-by-case basis.
- three letters of recommendation from persons familiar with the applicant's academic potential,
- official Graduate Record Examination (GRE) scores,
- a letter of research/specialization interest, and
- a résumé/Curriculum vitae.

Applications must be submitted to the UTSA Graduate School through www.utsa.edu/graduate/. Incomplete applications will not be considered. Acceptance to the program is decided by the DSC. Full-time students accepted for the program are eligible for financial support in the form of competitive teaching assistantships, research assistantships, or research fellowships.

Funding All full-time students who apply to the ESE PhD program are automatically considered for program funding. Alternatively, students can secure funding by contacting directly individual faculty members in the ESE PhD program. Students supported with assistantships will be required to fulfill academic duties by working as a graduate research assistant, or a teaching assistant. Students receiving funding through these assistantships normally are responsible for covering their own medical insurance. Each assistantship is renewable on a yearly basis based upon student progress in the program. To qualify for renewal of funding, a student must be in good standing (i.e., maintain a 3.0 GPA and have fulfilled all their obligations as outlined in the original offer letter issued to them), and must be enrolled in 9 hours in the Fall Semester, 9 hours in the Spring Semester, and 3 hours in the summer semester.

IV. Degree Requirements

The Doctoral program in Environmental Science and Engineering requires that students complete a minimum of 60 semester credit hours beyond the Master's degree. This coursework includes courses that have been designed to provide advanced instruction in areas considered to form the foundation for the disciplines of environmental science and engineering. Enrollment in the Graduate Seminar is required for a minimum of 3 semester credit hours. A minimum of 15 semester credit hours of Doctoral Research and 15 semester credit hours minimum of Doctoral Dissertation must be completed prior to graduation. Any grade lower than "B" in graduate or remedial coursework at the undergraduate level does not count towards the 60 semester credit hours. Students can apply, with approval from the chair of their dissertation committee, up to 12 semester credit hours of graduate coursework to elective courses (see below), if not applied towards their M.S. degree. Students with only a baccalaureate degree are required to have a minimum of 75 semester credit hours to graduate with approval of the DSC.

18 semester credit hours of required electives are selected by the student with the approval of their dissertation committee. These elective courses may be offered by departments in the College of Sciences or the College of Engineering or by other departments at UTSA.

Dissertation Committee Students must choose a dissertation committee consisting of a chair and at least four additional graduate faculty members. The committee must include a minimum of one faculty member from the CEE Department and one from the College of Sciences. Students must submit the names of their dissertation committee to the DSC Chair by the end of their second semester of study.

The Written Qualifying Exams for the ESE PhD program are to be held twice per year, in the late spring and the late fall. Students are notified by the DSC Chair in writing when they should take the exam. For full time students, this normally takes place during the 1st year of study. Part-time students need to take the qualifying examination at a time dictated by the DSC. This is a take home exam held over a weekend period (noon Friday to noon Monday). It is intended to test the student's undergraduate background, their degree of understanding of the material presented in graduate courses, as well as their critical thinking in the following 5 general technical areas:

- Geology

- Hydrology
- Biology
- Chemistry and
- Environmental engineering

The exam questions are compiled by the DSC with input from all ESE PhD program faculty. In addition, a technical paper may be provided for critical review. Students can elect to answer questions in 4 out of the 5 technical areas listed above. The answers are graded by the faculty members that supplied them. The results of the exam are communicated to the students in writing by the DSC. No more than 2 attempts in passing the written qualifying exam are allowed.

Program of Study

Hours

A. Degree Core Curriculum

9

- | | | |
|-----|------|------------------------------------|
| CE | 6113 | Global Change |
| | | or |
| ENS | 5043 | Global Change |
| CE | 6273 | Analyses of Environmental Problems |
| | | or |
| ENS | 6273 | Analyses of Environmental Problems |

Choose a minimum of one of the following:

- | | | |
|-----|------|--|
| CE | 6043 | Risk and Decision Analysis in Civil Engineering |
| ENS | 5233 | Experimental Design and Analysis |
| ENS | 6033 | Multivariate Analysis in Environmental Science and Engineering |

B. Seminars

3

- | | | |
|-----|------|---|
| CE | 6221 | Graduate Seminar in Environmental Science and Engineering |
| | | or |
| ENS | 5981 | Graduate Seminar in Environmental Science and Engineering |

C. Doctoral Research and Dissertation

30

| | | | |
|---------------------------------------|--------|-----------------------|----|
| CE | 7211-3 | Doctoral Research | 15 |
| CE | 7311-3 | Doctoral Dissertation | 15 |
| | | or | |
| ENS | 7211-3 | Doctoral Research | 15 |
| ENS | 7311-3 | Doctoral Dissertation | 15 |
| D. Electives | | | 18 |
| Total semester credit hours required: | | | 60 |

The Oral Qualifying Exam and the Advancement to Candidacy Upon successful completion of the written qualifying examination and within the following two semesters, a student must notify the DSC in writing of their intention of taking the oral qualifying examination. The oral qualifying examination is a research proposal defense. The research proposal defense consists of the student's dissertation topic, the experimental approach, the research novelty, and the potential contribution to their scientific field. The student's dissertation committee chair must approve the student's research proposal before scheduling the oral examination. No more than two attempts to pass the oral examination are permitted.

Results of the written and oral examinations must be reported to the DSC and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy. After advancement to the candidacy, the student's dissertation committee can be changed at the student's request and with the approval of their dissertation committee chair and the chair of the DSC.

Dissertation Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The Dissertation Committee guides and critiques the candidate's research. The format of the dissertation document will follow the guidelines and rules published by the Graduate School and general University regulations in Chapter 6, Doctoral Degree Regulations.

Final Oral Dissertation Defense The student must notify the Graduate School in writing two weeks prior to the final scheduled oral defense. The final oral defense consists of public presentation of the dissertation, followed by a closed oral defense. Results of the oral defense must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.

V. Course Descriptions

CIVIL ENGINEERING (CE) COURSES

5013 Civil Engineering Systems Analysis

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Cross-listed. Systems approach to optimization and problem solving; operations research applications in civil engineering; mathematical modeling and analysis techniques including linear programming, dynamic programming, decision analysis and use of software to solve linear and nonlinear programming problems.

5023/ME 5483 Finite Element Method

(3-0) 3 hours credit.

Derivation and computer implementation of the finite element method for the solution of civil engineering boundary value problems.

5043 Advanced Civil Engineering Statistics

(3-0) 3 hours credit.

Statistical analysis methods include descriptive statistics, interval estimation and hypothesis testing, analysis of variance, design of experiments, regression analysis, and time series analysis. Additional topics covered include probabilistic methods, decision analysis and reliability analysis applied to civil engineering systems.

5103 Advanced Steel Design

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Connection design, welded and bolted, moment-resistant connections, plate girders, column stability, bracing design, and seismic design of frames.

5123 Bridge Engineering

(3-0) 3 hours credit.

Design loads, load distribution, design of superstructures and substructures, and evaluation and load rating capacity of bridges.

5133 Advanced Reinforced Concrete

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Design of statically determinate and indeterminate structures, estimation of prestress loss, flexure and shear strength, deflections and stress control, composite construction, and continuous span theory.

5143 Numerical Methods in Civil Engineering

(3-0) 3 hours credit.

Mathematical equation root finding and optimization methods, matrix equations, solution methods, eigenvector and eigenvalue solution methods, finite difference methods, curve-fitting methods, numerical integration and differentiation techniques, and introduction to finite element formulations.

5153 Prestressed Concrete

(3-0) 3 hours credit.

Design of statically determinate and indeterminate structures, estimation of prestress loss, flexure and shear strength, deflections and stress control, composite construction, continuous span theory, anchorage zone design and detailing.

5213 Industrial Waste Treatment

(3-0) 3 hours credit.

Survey of industrial wastewater characteristics, design methodology for biological, chemical and physical treatment processes, selection of appropriate processes, and economic optimization.

5293 Geographic Information Systems (GIS)

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Introduces vector, raster and tabular concepts, emphasizing the vector approach. Topics include: spatial relationships, map features, attributes, relational database, layers of data, data ingesting, digitizing from maps, projections, output, applications, and availability of public data sets. Will be placed on spatial/temporal data analyses using digitized maps and database information in an area of CE specialization.

5303 Hydrometeorology

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

The main objective of this course is to familiarize the student related to local and global distribution of freshwater. Conceptualizations of the water balance/budget are developed using principle of physical hydrology and meteorology. Emphasis will be on recent research and modern methods for data analysis and modeling. Real life events and phenomena will be discussed. In addition to the text, material will be presented from other sources. Guest instructors will give presentations on some case studies.

5403 Advanced Characterization of Highway Materials

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Basic and advanced level of the fundamentals of material response to static and repeated loading; emphasis on the deformation and fatigue behavior of asphalt mixtures, constitutive modeling for mixtures, microstructure characterization for mixtures, nondestructive testing of pavements, asphalt binder characterization, unbound materials (base and sub-base materials) evaluation and characterization.

5423 Advanced Pavement Analysis and Design

(3-0) 3 hours credit.

Asphalt concrete and portland concrete pavement analysis and design. Layered elastic, non-linear, and viscoelastic analysis. Slabs under environmental and traffic stresses. Software for layer analysis and slab analysis. AASHTO

1993 design method. Asphalt Institute and Portland Cement Association method. NCHRP 1-37A developed mechanistic-empirical design method.

5433 Advanced Geometric Design

(3-0) 3 hours credit

Course deals with the geometric design of highways and streets. Topics include highway functions, design controls and criteria, elements of design, local roads and streets, freeways, and intersections.

5443 Pavement Management

(3-0) 3 hours credit

Pavement evaluation and performance, evaluation of pavement distress condition surveys, evaluation of pavement roughness ride quality, skid resistance of pavements, evaluation of pavement structural capacity, maintenance and rehabilitation, prioritization and optimization of pavement maintenance, and rehabilitation needs.

5453 Transportation Engineering

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

Study of the Highway Capacity Manual, traffic stream parameters and relationships, analytical techniques in traffic engineering such as capacity analysis, queuing theory, and traffic simulation. Design and operation of advanced traffic management systems including signalization, real-time motorist information, urban incident management, and ITS concepts

5463 Foundation Engineering

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

A study of foundation engineering design, including excavation slopes and retaining walls, cofferdams, sheet-pile walls, caissons, drilled shafts, piles, settlement control methods, engineered fills, and foundations on expansive soils.

5503 Advanced Open Channel Hydraulics

(3-0) 3 hours credit.

Use of the state of the profession computer models to evaluate gradually varied and unsteady flows. The concepts of dimensional analysis and similitude will also be addressed.

5613 Environmental Chemistry

(3-0) 3 hours credit.

Cross-listed graduate-undergraduate technical elective course. Undergraduate course prerequisites: Junior or senior CEE standing, consent of the student's academic advisor, course instructor and CEE Chair.

This course explores the chemistry of the environment, the chemistry underlying environmental problems and solutions to environmental problems. Emphasis is placed on thermodynamics and kinetics of reaction cycles; sources, sinks and transport of chemical species; and quantitation of chemical species. Examples are selected from the chemistry of natural and contaminated air, water, and soil.

5623 Advanced Treatment Processes for Water Quality Control

(3-0) 3 hours credit.

Principles, modeling and design aspects of physical chemical treatment processes in drinking water, wastewater and groundwater remediation applications.

5633 Environmental Laboratory

(3-0) 3 hours credit.

Laboratory investigations are often utilized for characterizing water and waste quality and for evaluating the efficacy of treatment processes. This course is designed to familiarize students with common environmental engineering laboratory methods and appropriate analysis and presentation of laboratory data.

5703 Special Topics in Hydraulics and Hydrology

(3-0) 3 hours credit.

Course deals with a special aspect of Hydraulics and Hydrology. Topic may be varied and course can be repeated for credit.

5713 Special Topics in Structures

(3-0) 3 hours credit.

Course deals with a special aspect of structural engineering. Topic may be varied and course can be repeated for credit.

5723 Special Topics in Transportation

(3-0) 3 hours credit.

Course deals with a special aspect of Transportation Engineering. Topic may be varied and course can be repeated for credit.

5733 Special Topics in Environmental Engineering

(3-0) 3 hours credit.

Course deals with a special aspect of Environmental Engineering. Topic may be varied and course can be repeated for credit.

5743 Special Topics in Geotechnical Engineering

(3-0) 3 hours credit.

Course deals with a special aspect of Geotechnical Engineering. Topic may be varied and course can be repeated for credit.

5961 Comprehensive Examination

1 hour credit. Prerequisite: Approval of the student's advisory committee.

Independent study course for the purpose of taking the Comprehensive Examination. May be repeated for credit as many times as approved by the Civil Engineering Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination).

5973 Special Project

(3-0) 3 hours credit.

Work carried out by non-thesis Master ~~MS~~ students under the direction of their Advisory Committee to fulfill the project requirement of their degree. It may involve applied or theoretical work and a report documenting the findings.

- 5983 Master's Thesis**
3 hours credit. Prerequisite: Approval of the student's advisory committee.
Thesis research and preparation. It may be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.
- 5991 Graduate Seminar**
(1-0) 1 hour credit.
Graduate seminar may be repeated for credit for up to 3 semester credit hours.
- 6013 Hydrologic Modeling and Analysis**
(3-0) 3 hours credit.
This course will address hydrological modeling (both theory and practical applications with focus on the latter) and related issues. Multi-media and advanced visualization will be used in lectures and class work. Most of the course is dedicated to hands-on, problem-oriented applications using a variety of practical techniques. It will provide students with the knowledge and tools necessary to use data derived from geographical information systems (GIS) to develop hydrologic estimates needed for different applications.
- 6043 Risk and Decision Analysis in Civil Engineering**
(3-0) 3 hours credit.
Perspective of risk assessments, risk estimation, event tree analysis, fault tree analysis, risk classifications, risk acceptability, probabilistic modeling, anatomy of risks with revealed preference method, decisions under uncertainties, utility theory, multi-attribute utility functions, and case studies.
- 6103 Fate and Transport of Contaminants in the Environment**
(3-0) 3 hours credit
The course deals with the hydrodynamics of mixing and transport, as well as the interaction of mixing and various reaction rate processes. Applications in the course will include water and wastewater treatment, groundwater pollution, and transport and mixing in rivers, lakes and reservoirs. 3 credits
- 6113 Global Change**
(3-0) 3 hours credit.
Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Same as ENS 5043. Credit cannot be earned for both CE 6133 and ENS 5043.)
- 6123 Environmental Clean Up and Remediation**
(3-0) 3 hours credit.
Study of current remediation technologies for soil, water, and air. Includes selection criteria, costs, operating strategies, and engineering design.
- 6133 Landfill Engineering and Design**
(3-0) 3 hours credit.
Containment systems, site selection, clay mineralogy, clay liners, geosynthetic liners, chemical compatibility of liners, leachate collection system design, landfill cover and caps design.

6153 Advanced Mechanics and Modeling of Structural Materials

(3-0) 3 credit hours.

Constitutive models and strength theories for steel, concrete, reinforced concrete, soil and newly developed materials, such as composite laminates. Theoretical basis of beam, plate (slab), shell, frame analysis of structural components. Stability analysis of structural components; buckling of beams, plates, shells and frames. Correlated design requirements based on strength and stability analysis of structural components implemented in the ASCE code. Modeling of complicated, nonlinear behavior of structures under static and dynamic loadings, such as seismic, wind loading using finite element methods.

6221 Graduate Seminar in Environmental Science and Engineering

(1-0) 1 hour credit.

Will include presentations of current research by faculty and invited guests who are experts in various aspects of research in the environmental sciences and engineering, and advanced graduate students who are about to complete their dissertation research. May be repeated for credit.

6273 Analyses of Environmental Problems

(3-0) 3 hours credit.

Problems will be presented and potential solutions will be explored from a variety of areas including soil, air, water, coastal and marine systems. Also examined will be potential impact on biotic and abiotic resources in terrestrial, aquatic, and marine systems. (Same as ENS 6273. Credit cannot be earned for both CE 6273 and ENS 6273.)

6523 Advanced Surface Water Hydrology

(3-0) 3 hours credit.

Use of state of the profession computer models to study the rainfall-runoff process. Extreme events are the focus of the course (droughts and floods). Approaches to developing design precipitation events will also be presented.

6951-3 Independent Study

1 to 3 hours credit. Prerequisites: Written permission of the instructor and the student's advisory committee.

Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree.

7211-3 Doctoral Research

1 to 3 hours credit.

Prerequisites: Admission to Doctoral candidacy, consent of the student's dissertation committee and consent of the DSC. Credits reflect research work carried out by the student under the supervision of their dissertation committee. It may be repeated as necessary, but no more than 15 hours may be applied to the Doctoral degree.

7311-3 Doctoral Dissertation

1 to 3 hours credit.

Prerequisites: Successful defense of the oral defense, consent of the student's dissertation committee and consent of the DSC. Credits reflect dissertation work carried out by the student under the supervision of their dissertation committee. It may be repeated as necessary, but no more than 15 hours may be applied to the Doctoral degree.

ENVIRONMENTAL SCIENCE (ENS) COURSES

5013 Survey Topics in Environmental Science

(3-0) 3 hours credit. Prerequisite: Graduate standing.

Analysis of the basic concepts and new scientific developments in the Earth's changing environment systems and their links to human activities. Case studies will cover a range of relevant topics to promote a thorough understanding of the emergent issues in environmental sciences. Emphasis will be placed on developing both written and verbal scientific presentation skills.

5023 Environmental Statistics

(3-0) 3 hours credit. Prerequisites: MAT 1033 and STA 1993 or their equivalents, or consent of instructor.

Introductory course in systems analysis emphasizing its application for the management of environmental and public systems. Problem formulation, mathematical modeling, and procedures are introduced through case studies that include energy consumption, soil contamination, leak detection, and air pollution. In these case studies, students become acquainted with quantitative governmental regulations formalized by the Environmental Protection Agency. Quantitative tools include exploratory data analysis, design of experiments, analysis of variance, regression analysis, and time series. Optimization techniques are taught within regression analysis. (Formerly EES 5023 and ES 5023. Same as GS 5023. Credit can be earned for only one of the following: EES 5023, ENS 5023, ES 5023, or GS 5023.)

5043 Global Change

(3-0) 3 hours credit. Prerequisite: Graduate standing in the program or consent of instructor.

Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Formerly EES and ES 5043. Same as CE 6113 and GS 5043. Credit can be earned for only one of the following: CE 6113, EES 5043, ENS 5043, ES 5043, or GS 5043.)

5063 Environmental Microbiology

(3-0) 3 hours credit. Prerequisite: BIO 3713 or consent of instructor.

To provide a basic understanding of environmental microbiology primarily from two aspects: microbial interactions with chemical pollutants in the environment and the fate of microbial pathogens in the environment. Topics covered include microbial environments, detection of bacteria and their activities in the environment, microbial biogeochemistry, bioremediation, and water quality. (Formerly EES 5063. Same as BIO 5063. Credit can be earned for only one of the following: EES 5063, ENS 5063, or BIO 5063.)

5073 Environmental Microbiology Laboratory

(2-3) 3 hours credit. Prerequisite: BIO 3722 or consent of instructor.

To provide an understanding of environmental microbiology laboratory techniques using both traditional and molecular research skills. Basic techniques for isolation and characterization of environmental soil and water microflora including methods for enumeration and measurement of physiological activity. (Formerly EES 5073. Same as BIO 5073. Credit can be earned for only one of the following: EES 5073, ENS 5073, or BIO 5073.)

5103 Applied Ecology

(3-0) 3 hours credit.

The impact of humanity's activities on the environment: their effect on water, land, animal, and human resources. An evaluation of present and future strategies to preserve a healthy environment. (Formerly EES 5103, ES 5103, and ES 6203. Credit can be earned for only one of the following: EES 5103, ENS 5103, ES 5103 or ES 6203.)

5123 Project Analysis

(3-0) 3 hours credit.

This course examines the complex processes and factors in the evaluation of large-scale projects involving natural resources. It brings together the tools required to evaluate the physical, economic, financial, legal, and political constraints of these projects. (Formerly EES 5123, ES 5123, and ES 6873. Credit can be earned for only one of the following: EES 5123, ENS 5123, ES 5123, or ES 6873.)

5213 Environmental Geology

(3-0) 3 hours credit. Prerequisite: GEO 4063 or consent of instructor.

Geologic materials and processes as related to their influence on the human physical environment. Effects of landscape modification and geologic hazards such as earthquakes and landslides. Properties of minerals, rocks, and soils and geologic aspects of waste disposal and water resources are examined. (Course cannot be used for graduate credit by students in Geology.) (Formerly EES 5213 and ES 5213. Credit can be earned for one of the following: EES 5213, ENS 5213, or ES 5213.)

5233 Experimental Design and Analysis

(3-0) 3 hours credit. Prerequisite: ENS 5023 or an equivalent, or consent of instructor.

Fundamental concepts of the statistical design and analysis of environmental experiments will be presented. Students will be required to design experiments and to analyze data using computer software. (Formerly EES 5233 and ES 5233. Credit can be earned for only one of the following: EES 5233, ENS 5233, or ES 5233.)

5243 Advanced Plant Ecology

(3-0) 3 hours credit. Prerequisites: BIO 3283 and BIO 3292, or consent of instructor.

A study of the major biomes of the world, including North America and Texas, and the factors that influence the development of these biomes. Special consideration is given to species interactions that lead to high and low density species. (Formerly EES 5243 and ES 5243. Same as BIO 5243. Credit can be earned for only one of the following: EES 5243, ENS 5243, ES 5243, or BIO 5243.)

5253 Contaminant Transport in Porous Media

(3-0) 3 hours credit.

The transport of contaminants in a subsurface environment. Effects of dispersion, interphase mass transfer, transformation reactions, and porous-media heterogeneity on transport: covers aqueous (dissolved) and multiphase (immiscible liquid, gas) systems. (Formerly EES 5253. Credit cannot be earned for both ENS 5253 and EES 5243.)

5263 Microbial Ecology

(3-0) 3 hours credit. Prerequisite: BIO 3713 or consent of instructor.

Interrelationships between microorganisms and their environment, including natural habitats of microorganisms, normal human flora, and pathogens. Special consideration is given to application of genetically engineering microorganisms for environmental problems. (Formerly ES 5263. Same as BIO 5263. Credit can be earned for only one of the following: EES 5263, ENS 5263, ES 5263, or BIO 5263.)

5493 Water Pollution Control

(3-0) 3 hours credit.

Principles and methods of water pollution control process design and operation; selection and optimization of total treatment processes as well as appurtenances and accessory equipments; and methods involved in the design process and the selection of the hardware. (Formerly EES 5493 and ES 5493. Credit can be earned for only one of the following: EES 5493, ENS 5493, or ES 5493.)

5503 Environmental Policy and Law

(3-0) 3 hours credit.

Current environmental enabling acts and regulations are covered, with emphasis on federal acts, such as the National Environmental Policy Act, Clean Water Act, Resource Conservation and Recovery Act, and associated regulations. Management strategies for environmental compliance are also presented. (Formerly EES 5503 and ES 5503. Same as PAD 5483. Credit can be earned for only one of the following: EES 5033, ENS 5503, ES 5503, or PAD 5483.)

5743 Plant-Microbe Interactions

(3-2) 3 hours credit. Prerequisite: A 2000-, 3000- or higher-level microbiology or plant physiology course, or consent of instructor.

The study of molecular and cellular aspects of the interaction between plants and microorganisms in the environment, such as mycorrhizae, pathogenic fungi, *Agrobacterium*, pathogenic bacteria and plant viruses. Topics include microbial virulence, signaling, gene expression, and disease resistance in plants. Laboratory will focus on plant biochemical and microbiological methods as they relate to environmental problems. (Formerly EES 5743. Credit cannot be earned for both ENS 5743 and EES 5743.)

5971-3 Directed Research

1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's Graduate Advisor of Record.

The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. (Formerly EES 5971-3 and GEO 5971-3.)

5981 Graduate Seminar in Environmental Science and Engineering

(1-0) 1 hour credit. Prerequisite: Graduate standing in the program or consent of instructor.

Topical issues of current research will be examined. Presentations will be by current faculty, invited guests and Master's or Doctoral candidates. May be repeated for credit but only 2 hours may be applied toward the Master's degree. (Formerly EES 5981 and ES 5991. Credit cannot be earned for both EES 5981 and ES 5991.)

6003 Risk and Decision Analysis

(3-0) 3 hours credit. Prerequisite: ENS 5023 or consent of instructor.

Advanced application of systems analysis to the solution of environmental problems and the building and solving of mathematical models. The role of analytical tools such as cost analysis, decision, and utility theory as they are applied to the efficient utilization of natural resources are also covered. (Formerly EES 6003 and ES 6003. Credit can be earned for only one of the following: EES 6003, ENS 6003, or ES 6003.)

6013 Instrumental Environmental Methods for Environmental Analysis

(2-2) 3 hours credit. Prerequisite: One year of college chemistry or consent of instructor.

A survey of instrumental techniques and standard methods for analysis of environmental pollutants. Designed primarily for students interested in environmental management and remediation, the focus of the course will vary but will emphasize some aspect of environmental quality, water and soil in particular. (Formerly EES 6013 and ES 6013. Credit can be earned for only one of the following: EES 6013, ENS 6013, or ES 6013.)

6033 Multivariate Analysis in Environmental Science and Engineering

(3-0) 3 hours credit. Prerequisites: ENS 5023 and ENS 5233 or their equivalents, or consent of instructor. Fundamental concepts of Multivariate Analysis in Environmental Science and Engineering will be presented. Students will examine principle components, factor analysis, cluster analysis, multidimensional scaling, discriminate analysis, factor analysis, multivariate normal distributions, mean vectors and covariance matrix and tests of covariance matrices. (Formerly EES 6033. Same as CE 6033. Credit can be earned for only one of the following: EES 6033, ENS 6033, or CE 6033.)

6103 Environmental Impacts

(3-0) 3 hours credit. Atmosphere, lithosphere, hydrosphere, and biosphere are treated as interrelated systems. Human impact and interaction within and among these systems are studied. Preparation and evaluation of environmental impact statements and assessments are included. (Formerly EES 6103, ES 5203 and ES 6103. Credit can be earned for only one of the following: EES 6103, ENS 6103, ES 5203, or ES 6103.)

6113 Advanced Plant Physiology

(3-0) 3 hours credit. Prerequisite: BIO 4603 or consent of instructor. Principles of plant physiology and biochemistry, with particular emphasis on plant hormones, nitrogen fixation, plant respiration, photosynthesis, and current research work. (Formerly EES 6113 and ES 6113. Same as BIO 6113. Credit can be earned for only one of the following: BIO 6113, EES 6113, ENS 6113, or ES 6113.)

6123 Environmental Quality

(2-3) 3 hours credit. Prerequisites: A 2000- or 3000-level chemistry course, and ES 3024 or ES 3054, or consent of instructor. Principles of surface and aquatic chemistry as applied to soil and natural water systems. Application of aforementioned principles in the study of environmental quality issues will be included. Laboratory will focus on analysis of pollutants using modern analytical techniques. (Formerly EES 6123 and ES 6123. Credit can be earned for only one of the following: EES 6123, ENS 6123, or ES 6123.)

6133 Methods in Field Ecology

(3-0) 3 hours credit. Prerequisite: BIO 3283 or an equivalent. Examination of techniques to collect, identify, and preserve plants and animals. Field methods used in the analysis of populations and communities are considered. (Formerly EES 6133 and ES 6133. Same as BIO 6133. Credit can be earned for only one of the following: BIO 6133, EES 6133, ENS 6133, or ES 6133.)

6203 Aqueous Geochemistry

(2-3) 3 hours credit. Prerequisites: A 2000- or 3000-level chemistry course, and ES 3024 or ES 3054 or GEO 3374, or consent of instructor. An in-depth study of geochemical principles and practices focusing primarily on the aquatic environment. Designed to familiarize advanced students of Geochemistry, Environmental Science, and Environmental Engineering with those aspects of applied chemistry that have relevance in the care of environmental research

and practice. (Formerly EES 6203 and GEO 6203. Same as GS 6203. Credit can be earned for only one of the following: EES 6203, ENS 6203, GEO 6203, or GS 6203.)

6213 Advanced Ecology

(3-0) 3 hours credit. Prerequisite: BIO 3283 or an equivalent.

Interaction of organisms with their environment, allelopathy, competition, distribution, succession, and factors that control growth and dispersal. Special consideration is given to the concepts of climax, succession, and land management. (Formerly EES 6213 and ES 6213. Same as BIO 6213. Credit can be earned for only one of the following: BIO 6213, EES 6213, ENS 6213, or ES 6213.)

6253 Biodegradation of Organics in Soil and Groundwater

(3-0) 3 hours credit. Prerequisite: BIO 5123 or consent of instructor.

Description of modern pollution problems and potential remediation techniques focusing on the chemistry, biochemistry, and molecular biology of biodegradation of hazardous and toxic compounds. (Formerly EES 6253. Same as BIO 6253. Credit can be earned for only one of the following: BIO 6253, EES 6253, or ENS 6253.)

6273 Analyses of Environmental Problems

(3-0) 3 hours credit.

Problems will be presented and potential solutions will be explored from a variety of areas including soil, air, water, coastal and marine systems. Also examined will be potential impact on biotic and abiotic resources in terrestrial, aquatic and marine systems. (Formerly EES 6273. Same as CE 6273. Credit can be earned for only one of the following: CE 6273, EES 6273, or ENS 6273.)

6703 Environmental Biotechnology

(3-0) 3 hours credit. Prerequisites: ENS 5063 or ENS 5263, and ENS 5243, or consent of instructor.

Molecular methods for detection of microorganisms in the environment. Fate and survival of introduced organisms in the environment. Molecular mechanisms of microbial inactivation in waste treatment systems and microbial risk assessment. (Formerly EES 6703. Credit cannot be earned for both ESS 6703 and ENS 6703.)

6723 Advanced Environmental Regulations

(3-0) 3 hours credit. Prerequisite: ENS 5503 or equivalent, or consent of instructor.

A study of the environmental regulatory apparatus, and rules and regulations implemented to achieve those objectives of the environmental laws. (Formerly EES 6723. Same as CE 6723. Credit can be earned for only one of the following: CE 6723, EES 6723, or ENS 6723.)

6763 Environmental Phytoremediation

(2-3) 3 hours credit. Prerequisites: A 2000-, 3000-, or higher-level plant physiology, biochemistry or genetics course, and ES 3024 or ES 3054, or consent of instructor.

The study of environmental pollution effects on physiological and ecological processes of plants, in both managed and unmanaged ecosystems. Pollutants under study include contaminants of air (such as ozone, sulphur dioxide and UV-B radiation) and soil (such as metals and organic xenobiotics). Topics include principles, protocols and applications of molecular biology and biotechnology for genetic improvement of microbes/plants for environmental remediation. Laboratory will focus on plant biochemical, soil chemical and plant molecular biological methods and a group research project. (Formerly EES 6763. Credit cannot be earned for both ENS and EES 6763.)

6813 Water Resources

(3-0) 3 hours credit.

Application of management principles to the efficient use of water resources by people and their public and private institutions. Water is examined in terms of its value, use, and changing role in the context of economics, history, politics, and technology. (Formerly EES 6813 and ES 6813. Same as GS 6813. Credit can be earned for only for one of the following: ESS 6813, ENS 6813, ES 6813, or GS 6813.)

6901-3 Experimental Techniques in the Environmental Sciences

(1-0, 2-0, 3-0) 1 to 3 hours credit. Prerequisite: Consent of instructor.

Topics will include various research methods in environmental science. May be repeated for credit as topics vary. (Formerly EES 6901-3 and ES 6901-3. Unless topic varies, credit can be earned for only one of the following: EES 6901-3, ENS 6901-3, or ES 6901-3.)

6941 Environmental Science Colloquium

(1-0) 1 hour credit. Prerequisite: Graduate standing.

Discussions of current journal articles, reviews, and recent advances in specialized areas of the biological sciences. May be repeated for credit as topics vary. The grade report for this course is either “CR” (satisfactory participation in the colloquium) or “NC” (unsatisfactory participation in the colloquium). (Formerly EES 6941 and ES 6941. Same as BIO 7041. Unless topic varies, credit can be earned for only one of the following: BIO 7041, EES 6941, ENS 6941, or ES 6941.)

6951-3 Independent Study

1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student’s Graduate Advisor of Record.

Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master’s degree. (Formerly EES 6951-3 and ES 6951-3.)

6961 Comprehensive Examination

1 hour credit. Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination.

Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either “CR” (satisfactory performance on the Comprehensive Examination) or “NC” (unsatisfactory performance on the Comprehensive Examination). (Formerly EES 6961 and ES 6961.)

6963 Internship

3 hours credit. Prerequisites: Graduate standing and consent of Graduate Advisor of Record.

An opportunity for students to work in a setting that permits them to apply what they have learned in the formal instruction part of the program. May be repeated for credit, but not more than 3 hours will apply to the Master’s degree. (Formerly EES 6963 and ES 6963. Credit can be earned for only one of the following: EES 6963, ENS 6963, or ES 6963.)

6973 Special Problems

(3-0) 3 hours credit. Prerequisite: Consent of instructor.

An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, will apply to a Master's degree. Field trips may be required. (Formerly EES 6973, and ES 6973.)

6983 Master's Thesis

3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director.

Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. (Formerly EES 6983 and ES 6983.)

7211-3 Doctoral Research

1 to 3 hours credit. Prerequisite: Admission to candidacy for the Doctoral degree.

May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7211-3.)

7311-3 Doctoral Dissertation

1 to 3 hours credit. Prerequisite: Admission to candidacy for the Doctoral degree.

May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7311-3.)