COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY

Dr. Richard A. Alo', Dean

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Departments/Programs

- Department of Biology
- Department of Chemistry, Physics and Atmospheric Sciences
- Department of Civil and Environmental Engineering, and Industrial Systems and Technology
- Department of Electrical and Computer Engineering, and Computer Science
- Department of Mathematics and Statistical Sciences
- Graduate Engineering Programs
- Interdisciplinary Computational Data-Enabled Science and Engineering

The College of Science, Engineering, and Technology (CSET) was authorized in 2002, through an academic reorganization plan that combined the School of Science and Technology with the School of Engineering. The focal point of CSET's vision is the preparation of highly qualified and competitive graduates. Academic programs help to fulfill this vision, which is complemented by a faculty with a rich diversity of recognized scholars, and scientists who have established reputations around the world. A capable and energetic administration, with a well-trained staff, is in place to provide the knowledge, support and experiences required to ensure and enhance productivity in the academic environment.

DEPARTMENT OF BIOLOGY

Dr. Timothy Turner, Professor and Chair
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Faculty
Dr. H. A. Ahmad, Associate Professor
Dr. G. Begonia, Professor
Dr. M. Begonia, Professor
Dr. J. Cameron, Professor
Dr. I. Farah, Professor
Dr. B. Graham, Associate Professor
Dr. C. Howard, Professor
Dr. H. C. Huang, Assistant Professor
Dr. H. Hwang, Professor
Dr. R. Kafoury, Associate Professor
Dr. R. Kulawardhana, Assistant Professor
Dr. K. Ndebele, Associate Professor
Dr. F. Noubissi, Assistant Professor
Dr. M. Pacurari, Assistant Professor
Dr. A. Patlolla, Assistant Professor
Dr. J. Stevens, Professor
Dr. D. Sutton, Associate Professor
Dr. P. Tchounwou, Presidential Distinguished Professor
Dr. C. Yedjou, Associate Professor

Degree Programs
The Department of Biology in the College of Science, Engineering and Technology (CSET) offers graduate studies leading toward the 1) Master of Science (M.S.) in Biology, and 2) Master of Science (M.S.) in Environmental Science degrees. Both M.S. degrees are research-oriented and designed to satisfy academic requirements for those students intending eventually to seek degree(s) beyond the master's level.

Programs Objectives

1. To provide advanced academic and practical training at the master's degree level,
2. To contribute to the pool of biologists and environmental scientists qualified to undertake doctoral degree programs, and to obtain employment in industry, government and academic institutions, and
3. To offer a program that will enable biology and environmental science majors to obtain the necessary classroom, laboratory and/or field experiences required for entering areas in and related to biological and environmental sciences directly upon graduation.

Admissions Requirements

In addition to the requirements set forth by JSU's Graduate Studies, all applicants seeking admission to the M.S. in Biology and/or M.S. in Environmental Science programs in the Department of Biology must meet the following minimum admission requirements:

1. An undergraduate (B.S.) degree in biology or related field. For M.S. in Environmental Science program applicants, at least 16 credit hours of biology courses are required,
2. A minimum undergraduate grade point average (GPA) of 3.00 or higher as evidenced by an official transcript from all accredited colleges and universities attended (Note: Conditional admission may be assigned to applicants who possess a cumulative GPA of at least 2.50-2.99 at the undergraduate level (on a 4.0 scale) and meet other admission requirements),
3. Application for admission to JSU Graduate School.
4. Three letters of recommendation (sent directly to the Department), at least 2 from academic professors who can assess the applicant's: a) academic qualifications; b) written and oral communication skills; c) capacity for critical and analytical thinking; and d) overall potential for graduate studies; Letters of recommendation forms are available at the Graduate School's website
5. For International applicants: a satisfactory Test of English as Foreign Language (TOEFL) score; and a Certified Declaration of Financial Support filed with JSU,
6. A career goal statement (maximum of 800-1200 words),
7. A complete application package submitted before or on the following deadlines: March 1 for Fall semester; March 15 for Summer; and October 15 for Spring semester. (Incomplete and late applications (received after the deadlines may be evaluated.)

Transfer of Credits

Courses for which transfer credits are sought must have been completed with a grade of "B" or better. Approval is required by the Chair of the Department.

Time Limit

No student will be granted an M.S. degree unless all requirements are completed within a period of eight (8) consecutive calendar years from the time of admission to the program.

Residence

Students are required to spend one academic year in resident study on campus. One academic year may include two consecutive regular semesters or one regular semester and one adjacent summer session. To satisfy the continuous residence requirement, the student must complete a minimum of eighteen (18) hours for the required period.

Admission To Candidacy Requirements

When a minimum of 12-15 semester hours has been completed, the student should submit an application for advancement to candidacy. Please note that students cannot be advanced to candidacy until:

1. All admission requirements have been met.
2. Notification of the program option the student is electing, or that is required.
3. All incompletes ("I" grades) have been removed.
4. The Graduate English Competency Examination (GECE) was passed, or in the event of failure, ENG 500 must be passed with a grade of B or better
5. Earned a 3.00 cumulative G. P. A.
6. Filed the Application for Graduate Degree Candidacy with the approval of the Candidacy Committee.

Degree Requirements

A student seeking the M.S. in Biology or M.S. in Environmental Science degree must:

1. Complete a minimum of thirty (30) semester hours with a B or higher cumulative G.P.A. Six (6) of the required semester hours must be in Thesis Research
2. Pass the Graduate Area Comprehensive Examination (GACE) in 1 elective and 2 core/required courses.
3. Successfully defend the thesis before the Thesis Committee and public audience.
4. Submit an approved thesis to the Chair of the Department of Biology with one bound copy to the Department and one to the JSU library.
5. Completion of all departmental requirements.

Master of Science in Biology

Courses available for the M.S. degree in Biology provide 1) advanced preparation in biological and marine sciences, 2) provide preparation for advanced professional degrees elsewhere in zoology, plant science, marine science, environmental biology, environmental health, biomedical science, toxicology, genetics, immunology, physiology, microbiology, biochemistry, anatomy and other associated areas, 3) research careers in industry, government and academic institutions, and 4) preparation for professional degrees in medicine, dentistry, veterinary medicine, pharmacy and related health fields.

Required Courses

Course	Title	Semester Hours
BIO 511	Biostatistics	3
BIO 515	Molecular Biology	3
BIOL 515	Molecular Biology Laboratory	1
or		
BIO 540	Cell Biology	3
BIO 540L	Cell Biology Laboratory	1
or		
CHEM 531	Biochemistry	3
CHML 531	Biochemistry Laboratory	1
BIO 589	Graduate Seminar	1
BIO 599	Thesis Research	6
	Total Hours	14

Elective Courses (Total = 16 semester hours)
A student in consultation with his/her advisor and the graduate committee must select a minimum of sixteen (16) semester hours from departmental course offerings to complete degree requirements with emphasis in one of the following areas: Molecular Biology, Developmental Biology, Genetics, Microbiology, Plant Biology/Science, Anatomy and Physiology, Environmental Science, Marine Biology, and/or Invertebrate Zoology.

Master of Science in Environmental Science

The M.S. in Environmental Science program provides an education enabling of greater opportunities for employment in industry, state and government agencies or further education in the diverse field of environmental science. It also provides a cadre of trained individuals committed to using their environmental literacy toward the betterment of the environment and mankind.

Required Courses

Course	Title	Semester Hours
BIO 506	Human Environments and Natural Systems	3
BIOL 506	Human Environments and Natural Systems Lab.	1
BIO 511	Biostatistics	3
BIO 523	Ecology	3
BIOL 523	Ecology Laboratory	1
BIO 589	Graduate Seminar	1
BIO 599	Thesis Research	6
	Total Hours	18

Elective Courses (Total = 12 semester hours)
A student in consultation with her/his advisor and the graduate committee must select a minimum of twelve (12) semester hours from those areas and departments offering appropriate instruction.

Elective Courses
In addition to the required courses shown above, the student must complete a minimum of 16 semester hours (M.S. in Biology) and 12 semester hours (M.S. in Environmental Science) selected from the elective courses listed below. (*4 hours indicate 3 hours lecture and 1-hour laboratory).

BIO 509	General Genetics	*4
BIO 514	Methods in Environmental Analysis	3
BIO 515	Molecular Biology	4
BIO 516	Marine Botany	4
BIO 512	Natural Resources and Conservation	4
BIO 513	Advanced Human Nutrition	3
BIO 524	Plant Physiology	4
BIO 530	Advanced Microbiology	4
BIO 531	Invertebrate Zoology	4
BIO 533	Biology of Water Pollution	4
BIO 534	Ichthyology	4
BIO 540	Cell Biology	4
BIO 546	Selected Topics in Marine/Environmental	1-2
BIO 547	Introduction to Oceanography	4
BIO 550	Immunology and Serology	4
BIO 553	Tropical Marine Ecology	3
BIO 570	Human Physiology	4
BIO 575	Endocrinology	4
BIO 580	Limnology	4
BIO 602	Special Problems in Environmental Science	1-4
BIO 610	Environmental Microbiology	4
BIO 615	Principles of Bioremediation	4
CHEM 515	Environmental Chemistry	4
ITHM 520-531	Industrial/Technical Hazardous Materials Management courses	3-6

DESCRIPTION OF COURSES

BIO 501 Environmental Science (3 Hours). An introductory course for non-major graduate students dealing with the science of the environment and man's

relationships through political, social, economic, and ethical processes.

BIO 506 Human Environments and Natural Systems (3 Hours). Emphasis placed on fundamental problems that confront man from day to day. Topics among others for discussion are ecology, population, energy, food, and transportation and land pollution.

BIOL 506 Human Environments and Natural Systems Lab. (1 Hour) Selected laboratory exercises, visiting lectures and field trips are designed to provide a broad view of applications and concepts in environmental science.

BIO 507 Biology for Elementary Teachers. (3 Hours) Prerequisites: None. The application of biological procedures and techniques at the elementary school level with emphasis on selected topics in biology.

BIOL 507 Biology for Elementary Teachers Laboratory. (1 hour) Prerequisite: BIO 101. Laboratory designed to expand and illustrate subject-matter areas stressed in BIO 507.

BIO 508 Fundamentals of Electron Microscopy. (4 hours) Prerequisites: Senior, graduate level, and consent of instructor. To introduce the students to the techniques of electron microscopy so that they may be able to initiate their own biological investigations. Emphasis will be placed on laboratory work.

BIO 509 General Genetics. (4 Hours) Prerequisite; BIO 318. A study of the principal concepts of heredity to include the application of classical and modem genetics.

BIO 511 Biostatistics. (3 Hours) This course is designed for students in biological sciences with no advanced training in mathematics. Basic concepts in statistical methods and experimental techniques and their general applicability in biology will be stressed.

BIO 512 Natural Resources and Conservation (3 hours) A study of our natural resources with emphasis on their origin, properties, use and misuse and good conservation practices.

BIOL 512 Natural Resources and Conservation Lab. (1 hour) Students are involved in the collection of data concerning the use and the analysis of conservation practices for both domestic and public waste, water, and energy resources.

BIO 513 Advanced Human Nutrition. (3 hours) Prerequisites: BIO 233 or 218 and CHEM 241. Review of nutrient sources, requirements and deficiency diseases of man. Emphasis on nutritional metabolism under normal and pathological conditions, and current research.

BIO 514 Methods of Environmental Analysis. (3 Hours) Theory, methods and techniques for identifying and qualifying environmental contaminants. Sampling methods are discussed and some coverage is provided on methods for separation and concentration.

BIO 515 Molecular Biology. (3 Hours) Study of the structure, synthesis, isolation and interactions of macromolecules of biological interest.

BIOL 515 Molecular Biology Laboratory. (1 Hour) Prerequisite: Must be taken concurrently with BIO 515. Laboratory techniques used to purify proteins, DNA, and RNA and the methods used to analyze these macromolecules.

***BIO 516 Marine Botany**. (3 Hours) Prerequisites: BIO 119, BIOL 119, BIO 416; open to qualified undergraduates. Survey of seaweeds (marine algae), marine phytoplankton and maritime vascular plants, treating structure, reproduction, life histories, distribution and ecology. Lecture and laboratory to be taken during same semester.

***BIOL 516 Marine Botany Laboratory**. (1 Hour) Prerequisite: Must be taken with lectures in BIO 516. Collection, preservation and preparation and microscopic examination with purpose of emphasizing identification of seaweeds.

BIO 517 Introduction to Remote Sensing for Environmental Science. (3 hours) Prerequisites: PHY201, 202, MATH 111, 115, 231. This course introduces the theory and techniques of remote sensing and their application to environmental analysis. Topics include the concepts of remote sensing; characteristics of spectromagnetic waves; types of remotely sensed data; sensor types; the theory of photogrammetric techniques; digital image analysis for acquisition of geographical information. Several lab activities involve: learning of basics of ERDAS Imagine; data acquisition through Internet search for satellite images; importing datasets, band characteristics & visual presentation.

BIO 518 Application of Remote Sensing in Environmental Science. (3 hours) Prerequisite: BIO 517. This course covers the quantitative and applied aspects and analysis of remotely sensed digital data. This course is designed to provide an understanding of digital image processing, analysis, and interpretation techniques. Topics include digital data visualization; geometric, radiometric, and atmospheric correction; image enhancement and manipulation; information extraction; digital change detection; integration of GIS and remotely sensed data, and spatial modeling. Laboratory exercises are in-depth applications of the exercise topics that were covered in BIO 417/517 as well as thematic information extraction and change detection.

BIO 520 Biological Photography. (3 Hours) Prerequisite: Consent of instructor. The course is designed to equip students with the knowledge and expertise to produce high quality prints and slides. Emphasis is placed on laboratory work (darkroom).

BIOL 520 Biological Photography Laboratory. (1 Hour) Laboratory activities give the student experience in exposing and developing black and white films and making prints with various print papers. Must be taken concurrently with BIO 520.

BIO 521 Plant Morphology. (3 Hours) Prerequisite: BIO 119. Study of anatomical, reproductive, ontogenetic and phylogenetic aspects of vascular and non-vascular plants.

BIOL 521 Plant Morphology Laboratory. (1 Hour) Selection of exercises involving the structures, developments and relationships of nonvascular and vascular plants.

BIO 522 Plant Taxonomy. (3 Hours) Prerequisite: Bio 119. Classification and nomenclature of flowering plants; introductory method of collection; laboratory and field studies of representative plant families.

BIOL 522 Plant Taxonomy Laboratory. (1 Hour) Prerequisites: Botany 118, 119. Exercises on collection, classification and nomenclature of flowering plants.

BIO 523 Ecology. (3 Hours) Prerequisite: Senior standing or consent of instructor. A study of the tropic relationships and energy transfer in ecosystems.

BIOL 523 Ecology Lab. (1 Hour) This lab course is designed to be, and should be, taken concurrently with the Ecology lecture course (BIO 523). The ecology laboratory sessions are structured to reinforce topics discussed in lecture and provide a treatment of technical topics not covered in the lecture. Methods common to the laboratory and field will be taught. Students will 1) gain a deeper, understanding of the main concepts of ecology and ecological processes and 2) develop critical and analytical thinking skills along with reasoning and logical thinking skills, and apply them to ecological concepts.

BIO 524 Plant Physiology. (3 Hours) Prerequisite: BIO 119. Principal physiological processes of plants including water relation, synthesis, and use of foods and growth phenomena are discussed.

BIOL 524 Plant Physiology Laboratory. (1 Hour) Laboratory exercises will be continued to verify the principles of Plant Physiology.

***BIO 525 Introduction to Marine Geology**. (1 Hour) Prerequisites: BIO 408, 408A, or permission of instructor; open to advanced undergraduates. Introductory geology from the marine viewpoint; morphology and origin of ocean basins, plate tectonics, marine sedimentation, coastal features and marine georesources. Lecture and laboratory to be taken during same semester.

***BIOL 525 Introduction to Marine Geology Laboratory**. (1 Hour) Prerequisite: Must be taken with lectures in BIO 525. Field and laboratory exercises in recognition of geological features and specimens, study of techniques, core samples, mapping and marine topographic profiles.

BIO 526 Mycology. (3 Hours) Prerequisite: BIO 119. A survey of the principal fungal classes. Morphology and cytology of fungi and their relation to industry and agriculture.

BIO 528 Evolution. (3 Hours) Prerequisite: BIO 409 or the equivalent. A study of the processes of organic change. Historical developments of the major concepts and mechanisms. (S)

BIO 529 Plant Anatomy. (3 Hours) An introduction to cell division, development, and maturation of the structures of the vascular plants.

BIOL 529 Plant Anatomy Laboratory. (1 Hour) Selection of exercises involving cell division, development and maturation of the structures of vascular plants.

BIO 530 Advanced Microbiology. (3 Hours) Prerequisites: BIO 313; CHEM 242. Special techniques for culturing microorganisms. Includes a survey of some of the important microbes in medicine, industry and public health.

BIOL 530 Advanced Microbiology Laboratory. (1 Hour) Teaches the student special methods in isolating, culturing, and identifying certain microorganisms of medical and industrial importance. Must be taken concurrently with BIO 530.

BIO 531 Invertebrate Zoology. (3 Hours) Prerequisites: BIO 114, CHEM 142. Intended for students who wish to obtain a comprehensive knowledge of the invertebrates.

BIOL 531 Invertebrate Zoology Laboratory. (1 Hour) Prerequisite: Must be taken concurrently With BIO 531. A taxonomy consideration of the invertebrate fauna. Students are also introduced to empirical observation in such areas as ecology, physiology and behavior.

BIO 532 Advanced Parasitology. (3 Hours) Prerequisites: BIO 331; CHEM 142, 242. The physiology of specific parasite and host-parasite relationships will be studied in great detail. Clinical specimens will be studied.

BIOL 532 Advanced Parasitology Laboratory. (1 Hour) Prerequisite: BIO 331 and/or consent of the instructor. The course will emphasize the experimental approach to Parasitology. Important parasites of man and other animals will be studied from clinical specimens. Must be taken with BIO 532.

BIO 533 The Biology of Water Pollution (3 hours) Biological approaches to water pollution problems is discussed. The effect of pollution on life in aquatic environments is emphasized.

BIOL 533 The Biology of Water Pollution Lab. (1 hour) Selected laboratory exercises, instrument use, and field trips are designed to further enhance the student's awareness in water pollution effects, analysis and problem solving.

BIO 534 Ichthyology. (3 Hours) Prerequisites: BIO 115, BIOL 115; open to advanced undergraduates. Biology and classification of marine and freshwater fish; emphasis on identification and collecting. Lecture and laboratory to be taken during same semester.

BIOL 534 Ichthyology Laboratory. (1 Hour) Prerequisites: BIO 115, BIOL 115. Must be taken with lecture in BIO 534. Field collecting, sorting, preserving, classification of marine fish; emphasis on identification.

***BIO 539 Marine Microbiology**. (3 Hours) Prerequisites: BIO 313, BIOL 313, 416, and BIOL 416. Open to advanced undergraduates. A survey of the most important marine microorganisms; emphasis on bacteria, sampling techniques, enumeration of indicator organisms, isolation of pathogenic organisms from seafood. Lecture and laboratory to be taken during same semester.

***BIOL 539 Marine Microbiology Laboratory**. (1 Hour) Prerequisites: BIO 313, 416. Must be taken with lectures in BIO 539. Techniques in sampling, isolation, culture and enumeration of pathogenic and nonpathogenic marine microorganisms.

BIO 540 Cell Biology. (3 Hours) Prerequisites: BIO 111, 119 or 121, 313, and CHEM 241. Study of cell and function. Emphasis on bioenergetics, cell metabolism, cell signaling and current cell research.

BIOL 540 Cell Biology Laboratory. (1 Hour) Prerequisites: BIO 112,119, 313. Must be taken concurrently with BIO 540. Laboratory activities, which develop techniques for isolation of cellular proteins, gene expression and quantitative analyses of biomolecules.

BIO 544 Arthropod Disease. (3 Hours) Prerequisites: BIO 115, 427. Emphasis is given to the control and prevention of insect and other arthropod borne diseases, the physiology, taxonomy, life cycles and ecology of important vectors.

BIOL 544 Arthropod Disease Laboratory. (1 Hour) Study the external structure and make outline sketches to indicate the characteristics used in classification of representative forms and unknown specimens of organisms important to medicine and veterinary science.

BIO 546 Selected Topics in Marine and Environmental Studies. (1-2 Hours) Prerequisites: None; open to advanced undergraduates or others on consent of instructor. Lectures on a broad range of marine and environmental topics of general interest having special application to students in both marine sciences program. No separate laboratory.

***BIO 547 Introduction to Oceanography**. (3 Hours) Prerequisites: BIO 407, BIOL 407. CHEM 254 and CHML 254, or consent of instructor; open to advanced undergraduates. Broad view of the marine world, geological, geographical, chemical, physical and biological; field trips aboard research vessels and laboratories introducing applied uses of oceanographic gear, instruments and sampling techniques. Lecture and laboratory to be taken during same semester.

***BIOL 547 Introduction to Oceanography Laboratory**. (1 Hour) Prerequisite: Must be taken with lectures in BIO 547. Introduction to oceanographic gear, its application methodology arid sampling techniques; field work in practical applications.

BIO 550 Immunology and Serology. (3 Hours) The study of antibodies that are elicited in response to antigens and the difference between the protoplasm of one organism and another as reflected in the blood.

BIOL 550 Immunology and Serology Laboratory. (1 hour) Prerequisite: BIO 313 Experimental application of immunology and serology in diagnosis of microbial diseases In vitro and in vivo techniques in immune response will be investigated.

BIO 553 Tropical Marine Ecology (3 hours) Opportunity for practical field exercises in selected tropical environments.

BIO 570 Human Physiology. (3 Hours) Prerequisites: BIO 115, CHEM 242. The study of physiological processes related to the human. The physiological systems to be examined are: gastro-intestinal, renal, endocrine, neural, and reproductive.

BIOL 570 Human Physiology Laboratory. (1 Hour) Selected studies of the physiological processes of mammals with emphasis on man. Must be taken concurrently with Bio 570.

BIO 575 Endocrinology. (3 Hours) Prerequisites: BIO 115, 218; CHEM 142, 242. The basic fundamentals of endocrinology. The role of the endocrine glands and their products (hormones) in the maintenance of a constant internal environment in living organisms.

BIOL 575 Endocrinology Laboratory. (1 Hour) Prerequisites: BIO 115, 218; CHEM 142, 242. Must be taken concurrently with BIO 575, or with the consent of the instructor. Experimental analysis of normal and abnormal endocrine functions. Emphasis is placed on basic laboratory techniques employed in the study of endocrine function.

BIO 576 Histopathology. (3 Hours) Prerequisites: BIO 115, 218, and 441. Provides general consideration of the principal concepts of tissues and cellular pathology, with emphasis on human tissues and pathology. The course prepares students for further studies in medicine, dentistry, and allied health fields.

BIOL 576 Histopathology Laboratory. (1 Hour) Exercises studying gross and microscopic diseased tissues and clinical cases.

BIO 580 Limnology (3 hours) Physical and chemical factors affecting the biology of ponds, reservoirs, and streams is presented. A research project in limnology will be required.

BIOL 580 Limnology Lab. (1 hour) Both chemical and biological monitoring of aquatic systems will be explored. Hack kits, conductivity meters, and oxygen probes, BOD's, COD's and map surveys will be utilized.

BIO 587 Independent Study. (2 hours for M.S. students) Prerequisite: Graduate standing in biology. Students will elect a specific topic that is not covered in other biology courses. The student, working independently, will be required to submit a research paper that includes an exhaustive review of literature.

BIO 589 Graduate Seminar. (1 hour for M.S. students) A course designed for survey of biological literature. The student will be required to prepare and present reports and assigned projects. Required of all students.

BIO 590 Reproductive Physiology. (3 Hours) Prerequisites: BIO 115, CHEM 142, 242. Some prerequisites may be waived with approval of instructor. An advanced assessment of the physiology metabolism and histology of the reproductive system. The etiology of abnormal functions will be presented.

BIOL 590 Reproductive Physiology Laboratory. (1 Hour) Prerequisites: BIO 112, 218, CHEM 142, 242. Must be taken concurrently with Bio 590 or with consent of instructor. Experimental analyses of the Mammalian reproductive system. Emphasis is placed on basic methodologies employed in anatomical and physiological studies of the reproductive system.

BIO 591 Advanced Developmental Biology. (3 Hours) Prerequisites: BIO 112, CHEM 242. Current experimental findings in the field of developmental biology will be presented. Theories on the mechanisms regulating differentiation and abnormal growth pattern will be discussed.

'BIOL 591 Advanced Developmental Biology Laboratory. (1 Hour) Advanced laboratory techniques in the field of developmental biology will be presented and analyzed.

BIO 599 Thesis Research, (required for M.S. students) (6 Hours) Thesis representing original research.

BIO 600 Graduate Seminar Advanced topics investigated are presented by students. The student will be required to prepare and present reports and assigned projects. Required of all students.

BIO 601 Environmental Science Seminar Advanced topics of special interest, current research, field trips, demonstrations, and guest lectures in the areas of environmental science, limnology, ecology, water and air pollution, populations, solar energy, earth resources, and others.

BIO 602 Environmental Science Special Problems (4 hours) Each student will select an aspect of the environment beyond the limits of the campus. The student will define the problem, analyze it, and report on his findings and possible solutions. This problem will sometimes include on the job training with an environmental agency.

BIO 609 Advanced Genetics. (4 Hours) Prerequisite: BIO 509. Provides detailed considerations of genetic analysis, quantitative inheritance, chromosomal engineering and some concepts in genetics.

BIO 610 Environmental Microbiology (3 hours) The study of the roles of microorganisms in natural systems with attention given to the examination of nutrient cycles, methods of analysis of microbial biomass and activities as well as the functional roles of microorganisms.

BIOL 610 Environmental Microbiology Lab. (1 hour) Laboratory is designed to acquaint students with modern techniques for measuring microbial biomass and microbial degradative activities of natural and xenobiotic chemicals in natural environments. Specific projects of microbial analysis will be assigned to students.

BIO 615 Principles of Bioremediation (3 Hours) This course uses modern knowledge in life sciences, as well as new developments in biotechnology to address important issues related to environmental cleanup of hazardous wastes. The nature of environmental pollution is reviewed, and basic concepts in molecular biology, biochemistry, and microbiology and plant physiology are applied to demonstrate the significance of bioremediation and phytoremediation in pollution control. Therefore, an emphasis is put on the use of biological methods and processes for the remediation of contaminated soils and water resources.

BIOL 615 Principles of Bioremediation (1 Hour) Laboratory and field experiments conducted to familiarize students and methodologies. Identification and classification of microorganisms' use of bacteria in toxicity assessment, biodegradation of organic contaminants, and phytoremediation of toxic metals are discussed.

BIO 617 / BIOL 617 Introduction to Remote Sensing for Environmental Science. (4 hours) Prerequisites: PHY 201, 202, MATH 111, 115, 231. This course introduces the theory and techniques of remote sensing and their application to environmental analysis. Topics include the concepts of remote sensing; characteristics of spectromagnetic waves; types of remotely sensed data; sensor types; the theory of photogrammetric techniques; digital image analysis for acquisition of geographical information. Several lab activities involve: learning of basics of ERDAS Imagine; data acquisition through Internet search for satellite images; importing datasets, band characteristics & visual presentation.

BIO 618 Application of Remote Sensing in Environmental Science. (3 hours) Prerequisite: BIO 617) This course covers the quantitative and applied aspects and analysis of remotely sensed digital data. This course is designed to provide an understanding of digital image processing, analysis, and interpretation techniques. Topics include digital data visualization; geometric, radiometric, and atmospheric correction; image enhancement and manipulation; information extraction; digital change detection; integration of GIS and remotely sensed data, and spatial modeling. Laboratory exercises are in-depth applications of the exercise topics that were covered in BIO 617 as well as thematic information extraction and change detection.

BIO 620 Independent Study Students will elect a specific topic that is not covered in other biology courses. The student, working independently, will be required to submit a research paper that includes an exhaustive review of literature.

BIO 621 Advanced Plant Morphology. (4 Hours) Prerequisite: BIO 521. Analysis and morphology of vascular plants ranging from pteridophyta through angiosperms with phylogenetic considerations.

BIO 650 Analysis of Hormone Action. (3 Hours) Prerequisite: Graduate status and consent of the instructor. An analysis of the cellular mechanisms of hormone action. The role of target tissues, receptors, hormone analogs and, metabolic inhibitors in studies of hormone action will be discussed.

**These courses (or close equivalents) also may be taken during summers at the Gulf Coast Research Laboratory, Ocean Springs, Mississippi; Dauphin Island Sea Laboratory, Alabama, or other coastal teaching/research laboratory for credit at JSU subject to approval on individual basis by JSU administration and coastal laboratory administrators.*

Doctor of Philosophy
ENVIRONMENTAL SCIENCE

Dr. Paul Tchounwou, Presidential Distinguished Professor and Director

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E-mail: kenneth.ndebele@jsums.edu

Faculty
(Interdisciplinary, listed by their Primary Department)
Biology:
Dr. G. Begonia, Professor
Dr. M. T. Begonia, Professor
Dr. I. Farah, Professor
Dr. C. Howard, Professor
Dr. H. Hwang, Professor
Dr. R. Kafoury, Associate Professor
Dr. R. Kulawardhana, Assistant Professor
Dr. A. Mohamed, Professor Emeritus
Dr. A. Patolla, Assistant Professor
Dr. J. Stevens, Professor
Dr. D. Sutton, Associate Professor
Dr. C. Yedjou, Associate Professor
Chemistry, Physics and Atmospheric Sciences:
Dr. Z. Arslan, Associate Professor
Dr. M. Fafavi, Professor
Dr. A. Hamme, Professor
Dr. F. Han, Professor
Dr. A. Hossain, Professor
Dr. J. Leszczynski, Presidential Distinguished Professor
Dr. Y. Liu, Professor
Dr. D. Lu, Assistant Professor
Dr. P. Ray, Professor
Dr. S. Reddy, Associate Professor
Civil and Environmenal Engineering and Industrial Systems and Technology:
Dr. K. Ali, Professor
Dr. F. Amini, Professor
Dr. Y. Li, Associate Professor
Dr. R. Whalin, Professor
Dr. P. C. Yuan, Professor
Electrical and Computer Engineering, and Computer Science:
Dr. N. Meghanathan, Associate Professor
Dr. L. Moore, Professor
Dr. M. Manzoul, Professor
Dr. G. Skelton, Professor
Dr. J. Walker, Professor
Mathematics and Statistical Sciences:
Dr. T. Kwembe, Professor

Program Mission
To produce highly skilled environmental scholars who in turn will provide for policy makers and the general public, scientific and factual information derived from laboratory and field applied research encompassing basic sciences, engineering and technology. As such, it is related to the assessment of water contamination, food contamination, air pollution, global warming, toxic and hazardous substances releases and associated environmental issues; and the development of cost-effective methodologies and strategies to protect the environment and human health.

Program Objectives
1. To provide graduate students with essential knowledge, skills and aptitudes needed for successful careers in environmental science related jobs at various institutions including government agencies, academia and the environmental industry.
2. To protect the environment and human health by educating and training students on the interactions between the various components/systems of the environment, the complex and fragile nature of the environment, and how to sustain ecosystem integrity and protect human health.
3. To establish applied environmental science research initiatives that will lead to an authoritative base of knowledge concerning the State of Mississippi's environment and natural resources; by assessing and understanding the mechanisms by which physical, chemical, and biological agents generated by nature may cause alterations of ecosystem integrity, disability and diseases in man and other life forms.
4. To develop and understand cost-effective methodologies and means whereby the impact of various environmental pollutants may be prevented and/or controlled, and to integrate important knowledge and technologies in the physical, chemical, biological and social sciences needed to set policies and guidelines for appropriate utilization and management of vital resources.
5. To render services to the community through outreach programs, technology transfer for the protection of natural resources and the development of the economy, and communication to convey environmental science education to the public.

Admission Requirements
Admission to the doctoral program in Environmental Science is open to persons holding the master's degree

in science, technology, engineering, or agriculture; demonstrated satisfactory performance on the Graduate Record Examination (GRE), and the Test of English as Foreign Language (TOEFL) for international students; and acceptable academic records.

All students seeking admission to this Ph.D. Program must meet the following criteria:

1. A Master's degree in natural sciences or related sciences from an accredited university. *An applicant with a Bachelor's degree only may be admitted when that student shows exceptional potential as determined by a GPA of **3.35** or better, a satisfactory GRE, and extraordinary work experience*,
2. A completed program application submitted to the Graduate School,
3. An official score on the Graduate Record Examination (GRE),
4. An overall GPA of 3.25 or above (on a 4.0 scale) on the highest earned degree,
5. Transcripts for all post secondary and graduate work attempted prior to a program application,
6. Recommendations from three major graduate professors knowledgeable of the applicant's professional academic ability, job experiences, and leadership and research potential,
7. Acceptable evidence of a student's writing ability as determined by a writing sample,
8. A satisfactory TOEFL score for international students,
9. A successful interview with the program screening committee, and,
10. Recommendation for admission by the program screening committee.

All applications received are reviewed by a standing Environmental Science Doctoral Advisory Committee that recommends acceptance or denial of admission to the Graduate School. The Graduate School officially informs the prospective student of its decision for the University.

Transfer Credits
A maximum number of nine credit hours can be transferred into the Program. Courses for which transfer credits are sought must be at least 700-Level; must have been completed with a grade of B or better; and must be approved by the student's Advisory Committee, the Environmental Science Advisory Committee, the Dean of the College of Science, Engineering and Technology, and the Dean of the Division of Graduate Studies. Credit for thesis or dissertation research as well as "internship" course work in any form is not transferable.

Time Limit
No student will be granted a doctoral degree unless all requirements are completed within a period of ten (10) consecutive calendar years from the time of admission to the program.

Financial Aid
Graduate research and teaching assistantships are available on a competitive basis to highly qualified students.

Residence
Students are required to spend one academic year in resident study on the campus. One academic year may include two adjacent regular semesters or one regular semester and one adjacent summer session. To satisfy the continuous residence requirement, the student must complete a minimum of eighteen (18) hours for the required period.

Candidacy Requirements
To be admitted to candidacy for the doctoral degree, a student must have:

1. Completed the formal coursework with a GPA of 3.0 or better.
2. Passed the Comprehensive Examination.
3. Filed with the Dean of the Graduate School, the dissertation proposal approved by the student's Advisory Committee, the Program Director and the Academic College Dean.

Degree Requirements
The program requires approximately two years of course work (40 semester hours) and a minimum of twenty (20) semester hours of dissertation research credit beyond the MS degree. The student's graduate committee will determine the exact program of study. Additional requirements include:

1. Satisfactory performance on the Comprehensive Examination administered after the student has completed all course work; and,
2. Successful defense of the dissertation research. The final basis for granting the degree shall be the candidate's grasp of the subject matter in a specialized area of environmental science, and a demonstrated ability to express thoughts clearly and forcefully in both oral and written languages.

Required Courses

Course	Title	Semester Hours
ENV 700	Environmental Systems	3
ENV 701	Environmental Chemistry	4
ENV 702	Environmental Health	3
ENV 711	Applied Environmental Biostatistics	3

ENV 751	Water Quality Management	3
ENV 755	Air Quality Management	3
ENV 800	Environmental Toxicology	4
ENV 801	Risk Assessment and Management	3
ENV 900	Environmental Science Seminar	2
ENV 999	Dissertation Research	20
	Total Hours	48

In addition to the required courses shown above, the student must complete a minimum of 12 semester hours selected from the elective courses listed below. Other electives in biological sciences, physical sciences, engineering, technology, and public policy will be added as developed.

Elective Courses

Course	Title	Semester Hours
CSC 700	Computer modeling	3
CSC 800	Image Interpretation	3
MATH 700	Statistics and Experimental Design	3
MET 800	Environmental Meteorology	3
ENV 715	Principles of Bioremediation	4
ENV 717	Introduction to Remote Sensing for Environmental Science	3
ENV 718	Application of Remote Sensing in Environmental Science	3
ENV 720	Environmental and Occupational Health	3
ENV 721	Solid Waste Management	3
ENV 780	Environmental Epidemiology	3
ENV 802	Environmental Physiology	4
ENV 803	Wetland Ecology	4
ENV 805	Medical Geology	3
ENV 830	Environmental Microbiology	4

The minimum total semester hours required for the doctoral degree is 60.

DESCRIPTION OF COURSES

ENV 700 Environmental Systems. (3 hours). Groundwork of environmental science, environmental awareness and ecological literacy for the incoming Ph.D. students is presented. The environment and its living and non-living components, and the interactions of these component areas studied. The course is set in a thermodynamic perspective and is based on a nested hierarchy of systems. Key concepts and principles that govern how we think the environment works are presented while learning how to apply these concepts to possible solutions of various environmental degradation, pollution and resource problems.

ENV 701 Environmental Chemistry. (3 hours). Prerequisites: One year of general Chemistry and one year of organic chemistry. Studies of the basic concepts of environmental chemistry; the nature of chemical compounds; organic and inorganic; chemical reactions; their effects, and fate of chemical species, in aquatic systems. This includes: Studies of equilibrium phenomena of acids, bases, salts, complex compounds, and oxidation/reduction reactions. Studies of water pollution, environmental chemistry of water and its properties.

ENVL 701 Environmental Chemistry (1 hour). Experiments done for the purpose of water quality control and assessment, such as the determination of alkalinity, acidity, water hardness, biochemical oxygen demand (BOD), and other important parameters. The laboratory is coordinated to go with the lecture material.

ENV 702 Environmental Health. (3 hours). This course focuses on the impact of environmental problems on human health. Health issues related to water pollution/contamination by physical, chemical and biological agents; wastewater discharges; radiations; air pollution; municipal, and industrial wastes; food contamination; pesticides; occupational hazards; and vector-borne diseases are discussed.

ENV 711 Applied Environmental Biostatistics. (3 hours) Prerequisite: Biostatistics (Bio 511) or equivalent. This course is designed as an applied, advanced biostatistics course for students in the Environmental Science Ph.D. Program. Students will learn how to apply important concepts and principles of environmental biostatistics in the conduct of their research, from the initial designing of experiments to proper data collection and analysis, inferences, interpretation of results in applied terms, reporting and presentation of the results. The statistical computer software (SAS) will be used to analyze and interpret results.

ENV 751 Water Quality Management. (3 hours). This course provides students with basic concepts and principles in Water Quality Management. The effects of organic, inorganic, biological and thermal pollutants/contaminants in various systems of the hydrologic cycle including streams, reservoirs, and estuaries; eutrophication; water quality criteria and standards; monitoring concepts; methods in water quality management; regulatory considerations; and non point source pollution control, are discussed.

ENV 755 Air **Quality Management.** (3 hours). This course provides students with basic concepts and principles of air quality management. Contaminant classification, pollutant sources, criteria pollutants, health effects, exposure and risk assessment are discussed. Pollutant measurements and air quality assessment techniques are considered with regard to

atmospheric effects on dispersion and transport. Identification of, and control strategies for, stationary and mobile sources, and environmental regulations are studied, and indoor air quality considered.

ENV 800 Environmental Toxicology. (3 hours). Prerequisites: ENV 701, ENV 702. This course is designed to provide an overview of the basic principles and concepts of toxicology including: exposure characterization, dose-response relationship, kinetics and distribution of toxicants in a biological system; to understand the fate, behavior and toxicities of xenobiotic chemicals, and the mechanisms by which they affect cells and organs; and to identify the sources and discuss the effects of various groups of environmental toxicants including heavy metals, pesticides and other industrial byproducts.

ENVL 800 Environmental Toxicology Lab. (1 hour). This course is designed to familiarize the students with important laboratory and field procedures and methods used in toxicological testing of environmental toxicants; and to discuss the strengths and weaknesses of major methodologies including acute, sub acute, sub chronic and chronic bioassays.

ENV 801 Risk **Assessment and Management.** (3 hours). Prerequisites: ENV 800, MATH 700. This course is designed to provide students with qualitative and quantitative skills necessary to evaluate the probability of injury, disease and death in humans and other life forms, from exposure to various environmental contaminants. Hazard identification, exposure assessment, dose-response evaluation and risk characterization are emphasized. Regulatory and technical aspects of risk assessment in the promulgation of public and environmental safety standards are discussed.

ENV 900 Seminar. (0.5 hr. x 4 semesters = 2 Hours) (Lecture). This course focuses on contemporary issues in environmental health science. The student is expected to review, discuss, and present orally a report on a topic related to contemporary environmental issues. Topic areas for selection include (but not limited to): environmental biology, environmental chemistry, environmental microbiology, environmental toxicology, atmospheric science, water quality management, solid and hazardous waste management, computer modeling and remote sensing. Students are required to attend all scheduled seminars.

ENV 999 Dissertation Research. (20 hours). Original research in one of several sub disciplines in Environmental Science. Credit per academic session allowable is 1-6 hours. Student must produce, present and defend a document of publication quality.

Elective Courses

CSC 700 Computer Modeling. (3 hours). The purpose of this course is to provide the student with the fundamental knowledge of simulation models, writing programs to generate random numbers from various probability distributions using differential methods, and testing the statistical properties of random number generators. The student will also be trained to write simple programs to simulate real life situation models using GPSS language.

CSC 800 Image Interpretation. (3 hours). This course presents a broad overview of various image processing concepts and techniques. Topics include the history of remote sensing, image digitation, data formats, hardware and software functions, commercial and public available digital processing systems, image preprocessing (radiometric and geometric correction), image enhancement, image classification, change detection, interfaces of remote sensing and geographical information system (GIS), and the future of digital image processing.

MATH 700 Statistics and Experimental Design. (3 hours) Prerequisite: MATH 272, or 2 semesters of Introductory Statistics. Probability; random variables; expectation of a function of random variables; sampling distribution; estimation; hypothesis testing; designed experiments; completely randomized design; randomized complete block design; Latin square design; factorial experiments; statistical software application to statistical analysis, are discussed.

MET 801 Environmental Meteorology. (3 hours). Principles of atmospheric science as applied to Gaussian modeling of pollutants. Includes source review and receptor identification and modeling, National Ambient Air Quality Standards and human health and welfare impacts, plume behavior, and access of EPA models, running of EPASCREEN, and web site information. Special topics covered include: scavenging; acid precipitation; weather modification, green house enhancement; stratospheric ozone; scrubbers; and indoor air quality.

ENV 715 Principles of Bioremediation. (3 hours). This course uses modern knowledge in life sciences, as well as new developments in biotechnology to address important issues related to environmental cleanup of hazardous wastes. The nature of environmental pollution is reviewed, and basic concepts in molecular biology, biochemistry, microbiology, and plant physiology are applied to demonstrate the significance of bioremediation and phytoremediation in pollution control. Therefore, an emphasis is put on the use of biological methods and processes for the remediation of contaminated soils and water resources.

ENVL 715 Principles of Bioremediation. (1 hour). Laboratory and field experiments conducted to familiarize students with relevant bioremediation techniques and methodologies. Identification and classification of microorganisms' use of bacteria in toxicity assessment, biodegradation of organic contaminants, and phytoremediation of toxic metals are discussed.

ENV 717 Introduction to Remote Sensing for Environmental Science (3 hours). This course introduces the theory and techniques of remote sensing and their application to environmental analysis. Topics include the concepts of remote sensing; characteristics of spectro-magnetic waves; types of remotely sensed data; sensor types; the theory of photogrammetric techniques; digital image analysis for acquisition of geographical information. Several lab activities involve: learning of basics of ERDAS Imagine; data acquisition through Internet search for satellite images;

importing datasets, band characteristics and visual presentation.

ENV 718 Application **of Remote Sensing in Environmental Science** (3 hours). Prerequisite: ENV 717. This course covers the quantitative and applied aspects and analysis of remotely sensed digital data. It is designed to provide an understanding of digital image processing, analysis, and interpretation techniques. Topics include digital data visualization; geometric, radiometric, and atmospheric correction; image enhancement and manipulation; information extraction; digital change detection; integration of GIS and remotely sensed data, and spatial modeling. Laboratory exercises are in-depth applications of the exercise topics that have been covered in ENV 717, as well as thematic information extraction and change detection.

ENV 720 Environmental and Occupational Health. (3 hours). This course explores the relationship and impact of the environment to health and illness in human populations. An exploration of man-made and natural environmental hazards will be discussed. Environmental health and risk assessment will be discussed as well as interventions. Environmental policy and practices will be viewed from the public health perspective and include the study of energy, waste, environmental justice, and regulation.

ENV 721 Solid Waste Management. (3 hours). This course emphasizes on waste control methodologies for both municipal and industrial wastes including hazardous and nonhazardous waste under the Resource Conservation and Recovery Act (RCRA). The students are familiarized with environmental legislation regulating these wastes at state and federal levels. A thorough review is done on waste handling, transport, treatment technologies including chemical, physical, biological and thermal treatments, and disposal options such as land disposal of wastes. Waste minimization techniques such as source reduction and recycling are also discussed.

ENV 780 Environmental **Epidemiology.** (3 hours) This course is designed to provide students with the basic knowledge and skills required to develop and apply epidemiologic principles and concepts to the study of adverse effects of various environmental factors on both human and ecological health. Emphasis is put on the study of the health effects of physical, chemical and biologic factors in the external environment, broadly conceived from the epidemiologic point of view. As such, it enables students to interpret epidemiological data and understand the approaches used in the epidemiologic investigations of acute and chronic diseases. The course also covers the basic methods and issues involved in epidemiologic investigation of disease conditions in human populations.

ENV 802 Environmental Physiology. (3 hours). This course provides students the basic concepts of homeostasis and adaptation to the environment. Discussions are designed to provide an understanding of the physiological responses to various types of pollutants in the different environmental systems including aerospace, hyperbaric, marine and terrestrial environments. Emphasis is placed on homeostatic responses at cellular, organ and organ system levels to various environmental stresses.

ENVL 802 Environmental Physiology Lab. (1 hour). Laboratory exercises are performed to introduce students to instrumental techniques necessary in the understanding of homeostatic regulatory mechanisms that permit adaptation of organisms to varied and peculiar habitats.

ENV 803 Wetland Ecology. (3 hours). This course is designed to provide scientific knowledge for a better understanding of interactions between biological, physical and chemical components of wetlands. The structure and function of various types of wetlands; their biodiversity, biogeochemistry, and the impact of pollution on their ecological characteristics are discussed. Discussions are also done on how constructed wetlands can be used as water quality enhancers.

ENVL 803 Wetland Ecology Lab. (1 hour). Emphasis is placed on field works designed to evaluate the physical, chemical and biological characteristics of wetlands.

ENV 805 Medical Geology. (3 hours). This course is designed to provide students with qualitative and quantitative skills necessary to examine and understand the impacts of the natural geologic materials and processes on the prevalence, incidence and distribution of human (and other animal) diseases. The course focuses on the understanding of the nature and behavior of geological factors, and the examination of their impacts on health. Hence, the course will encompass major local, national and global health issues impacted by geological materials and/or processes. It will also encompass the interactions between human activities, geological factors, environment and health, as well as the innovative technologies that are used for the characterization and impact assessment of geologic materials on health.

ENV 830 Environmental Microbiology. (3 hours). The general objective of this course is to study the roles of microorganisms in natural ecosystems. Attention is given to the examination of nutrient cycles, methods of analysis of microbial biomass and activities, and the functional roles of microorganisms. In addition, this course offers in-depth examination of the role of microbial processes related to environmental deterioration, its control and remediation, and ultimately its prevention.

ENVL 830 Environmental Microbiology Lab. (1 hour). Laboratory designed to acquaint students with modern techniques for measuring microbial biomass and microbial degradative activities of natural and xenobiotic chemicals in natural environments. Specific projects of microbial analysis will be assigned to students.

DEPARTMENT OF CHEMISTRY, PHYSICS AND ATMOSPHERIC SCIENCES

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Dr. T. Shahbazyan, Professor
Dr. H. Tachikawa, Professor Emeritus
Dr. J. D. Watts, Professor
Dr. L. White, Associate Professor
Dr. S. Yang, Assistant Professor
Dr. J. Zhou, Assistant Professor

Program Description
The Department of Chemistry, Physics and Atmospheric Sciences offers both a Doctor of Philosophy (Ph.D.) and a Master of Science (M.S.) degree in Chemistry, and Master of Science Teaching (MST). The Ph.D. degree in chemistry requires evidences of high quality scientific research leading to peer-reviewed publications with classroom teaching, laboratory supervising, and proposal and manuscript writing experiences. The program covers all modern areas of chemistry including analytical, biochemistry, computational, environmental, inorganic, organic, and physical chemistry, as well as interdisciplinary areas in material, energy, environmental, and biomedical research. The intensive graduate training includes formal lecture courses, hands-on laboratory and theoretical research experiences, teaching experiences, independent proposal development, preparation of manuscripts and preparation of research thesis/dissertation for publication.

Program Mission
The Department of Chemistry, Physics and Atmospheric Sciences aims at a comprehensive graduate education in all areas of modern chemistry and related fields for a diverse student body. These programs aim for national and international distinction and produce high quality chemists for education institutions, governmental agencies, and industrial and business entities.

Program Objectives
- To provide the best education and career opportunity for students from the underrepresented minority groups with a nurturing environment conducive to learning and scholarly activities.
- To provide opportunities in which students can develop methods of independent and systematic investigations leading to scientific discoveries.
- To prepare students for a successful career at academic institutions, industrial and business entities, and governmental agencies.
- To promote professional development and growth of the faculty.

Time Limits
For full-time students working toward an **M.S. degree**, the degree requirements should be completed by the end of the second year following the first semester of study. Students beyond their second year of full-time study will be reviewed by their Graduate Advisory Committee for satisfactory progress every semester. A report of unsatisfactory will result in dismissal from the program. Under special circumstances, MS students must graduate in three years in fulltime status. Part time students are considered separately.

For full-time students working toward a **Ph.D. degree**, we recommend that the final defense be completed within five years. Under special circumstances, Ph.D. students must graduate in eight years in fulltime status. Part time students are considered separately. Students beyond their fifth year of full-time study will be reviewed by their Graduate Advisory Committee for satisfactory progress every semester. A report of unsatisfactory will result in dismissal from the program. The student will be allowed to apply for a Master's degree in this case.

Doctoral Program in Chemistry
Admission Requirements
In addition to the requirements of the Division of Graduate Studies, applicants must have the following:

1. A B.S. degree in chemistry or a closely related field with passing grades 'C' or better for the following courses with labs:
   2 semesters of General Chemistry
   2 semesters of Organic Chemistry
   1 semester of Analytical Chemistry
   1 semester of Physical Chemistry
   1 semester of Inorganic Chemistry

2. GRE Score*
3. Three Letters of Recommendation
4. A Statement of Purpose for Graduate Study

(** Students who have difficulty taking the GRE can take the Department's entrance exam instead*)

Retention Requirements
In addition to satisfying the basic requirements of the Division of Graduate Studies, students are required to maintain a chemistry GPA of 3.00 or higher every semester. Seminar courses, dissertation courses, and other non-chemistry elective courses are excluded from the calculation of the chemistry GPA. Students whose chemistry GPA is below 3.00 will be placed on probation for up to one year to fix the deficiencies.

Repeating a Course
If a student receives a grade of "C" or lower in a chemistry core course or a course in the student's major field of study, that course must be retaken and the student must earn a grade of "B" or better.

Degree Candidacy Requirements
After completing the lecture and seminar course requirements, students need to take and pass the comprehensive examination and defend an independent research proposal in order to become an official Ph.D. candidate. The comprehensive examination of 3 subjects must be taken and passed during the second year of study and the written independent research proposal must be prepared and defended during the third year of study or at least one year before graduation.

Graduation Requirements
The minimum number of credit hours for the Ph.D. degree in Chemistry is 60 credit hours.

- A minimum of 18 credit hours from graduate chemistry lecture courses
- 2 credit hours for Seminars
- 40 credit hours for Dissertation Research
- Teach four semesters of undergraduate courses as a teaching assistant.
- Pass Area Comprehensive Examination in three subject areas.
- Write and defend an Independent Research Proposal.
- Defend the dissertation before the Dissertation Committee and public audience.
- Submit an approved dissertation to the Division of Graduate Studies with one copy to the Department and one to the University Library
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The 18 credit hours of lecture courses must include at least three out of the following five core courses for a total of at least 9 credit hours:

CHEM 723	Advanced Analytical Chemistry
CHEM 731	Advanced Biochemistry
CHEM 736	Physical Organic Chemistry
CHEM 741	Advanced Inorganic Chemistry
CHEM 758	Quantum Chemistry

Students entering the Ph.D. Program With a M.S. Degree in Chemistry
Students, who earned a M.S. degree from another institution, are allowed to transfer up to four (4) lecture courses or 12 credit hours if these courses are equivalent to the JSU chemistry doctoral courses. Students who earned a M.S. degree from JSU will be required to take at least two more approved lecture courses instead of the required six lecture courses. Other requirements are the same as for those entering the Ph.D. program with a B.S. degree.

Master's Program in Chemistry
Admission Requirements
In addition to the requirements of the Division of Graduate Studies, applicants must have the following:

1. A B.S. degree in chemistry or a closely related field with passing grade ("C" or better) in the following courses with labs
   2 semesters of General Chemistry
   2 semesters of Organic Chemistry
   1 semester of Analytical Chemistry
   1 semester of Physical Chemistry
   1 semester of Inorganic Chemistry
2. Three Letters of Recommendation
3. A Statement of Purpose for Graduate Study

Retention Requirements
In addition to satisfying the basic requirements of the Division of Graduate Studies, students are required to maintain a chemistry GPA of 3.00 or higher every semester. Seminar courses, dissertation courses, and other non-chemistry elective courses are excluded from the calculation of the chemistry GPA. Students whose chemistry GPA is below 3.00 will be placed on probation for up to one year to fix the deficiencies.

Degree Requirements
A student pursuing a M.S. degree in Chemistry is required to complete a minimum of 30 credit hours with a written thesis in Chemistry.

1. Within the 18 credit hours of lecture courses, students must complete at least three (3) of five (5) core courses for a total of nine (9) hour and two semesters of seminar for one (1) credit hour. The core courses are:

CHEM 523	Advanced Analytical Chemistry
CHEM 541	Advanced Inorganic Chemistry
CHEM 531	Biochemistry
CHEM 558	Quantum Chemistry
CHEM 536	Physical Organic Chemistry

2. Students will fulfill the remaining 11 hours from Chemistry electives with no more than 11 hours in CHEM 580-Thesis Research. It is possible to take some courses in related fields upon recommendation of the advisor.

3. Pass the Graduate Area Comprehensive Examination in three chemistry areas.
4. The student must participate as a teaching assistant in the chemistry department for at least two semesters.
5. Defend a thesis before the Thesis Committee and public audience.
6. Submit an approved thesis to the Division of Graduate Studies with one copy to the Department and one to the University Library

Non-Thesis Master's Degree
Ph.D. students who fulfill the following requirements will be awarded a Non-Thesis Master's degree in Chemistry, if the student applies and wishes to continue to finish the doctorate degree.

1. A minimum of 36 credit hours, including at least 18 hours of approved graduate level lecture courses and two hours of seminar with a GPA of 3.00 or better. The graduate lecture courses should include at least three of the five core courses: Advanced Analytical Chemistry, Advanced Inorganic Chemistry, Biochemistry, Quantum Chemistry, and Physical Organic Chemistry.
2. Pass the Graduate Area Comprehensive Examination.
3. Pass an oral defense covering the student's research before a committee of four faculty members. The quality of research should be at or above the level of a MS thesis.

Master of Science in Teaching

The Department of Chemistry, Physics and Atmospheric Sciences has the major teacher training responsibility in the College of Science, Engineering, and Technology. This program leads to the (MST) degree in Science Education with a concentration in one of the following areas: (Biology, Chemistry, General Science, Physics and Physical Science). The Department also offers for credit graduate science education and science content courses for graduate students of other programs. Several courses are offered for in-service teachers and other educators for professional development. These courses are often used toward certification and further degrees.

Accreditation
This program was accredited by the National Council for Accreditation of Teacher Education (NCATE). Currently the Department is in the process of renewing the accreditation of the program.

Program Objectives

1. To provide additional preparation for science teachers and science supervisors in scientific content and supervision techniques.
2. To enable teachers of science to gain insight into the kinds of science experience that is relevant to the needs of today's youth.
3. To develop in-science teachers an awareness of the modern trends and problems in science teaching.
4. To enrich current and potential science teachers and educators with content and pedagogy in science and science education areas.
5. To offer courses of use to different non-departmental graduate degree programs.

Admission Requirements
Hold a baccalaureate degree with a major or minor in one of the natural sciences from an accredited college or university.

Degree Requirements
A total of 30 semester hours plus a thesis (6 hours), 33 semester hours plus a project (3 hours), or 36 semester hours with neither a thesis nor project.

By the end of the first year, the student should complete the Graduate English Competency Examination (GECE). Students should take the Graduate Area Comprehensive Examination in all core science courses.

Master of Science in Teaching

Core Courses

Course	Title	Semester Hours
EDFL 515	Methods of Educational Research	3
EDFL 514	Elementary Statistics	3
EDFL 568	Curriculum Methods	3
	Hours	9
Science Education Core Courses		
SCI 502	General Science for Teachers	3
SCI 507	Earth Science	3
SCI 513	Computer Applications in the Teaching of Science	3
SCI 522	Environmental Science	3
SCI 563	Problems and Issues in Science	3
SCI 581	Operation Physics I	3
SCI 599	Thesis, *or*	6
SCI 587	Independent Study	
	Science Elective, *or*	3
	Two Science Electives	6
	Total Hours	36

DESCRIPTION OF COURSES

Master-level Courses in Chemistry

CHEM 511 Chemistry Seminar. (1 Hour) Presentation and discussion of current chemical topics

and research by students, faculty and visiting speakers. Prerequisite: Permission of instructor.

CHEM 523 Advanced Analytical Chemistry. (3 Hours) Prerequisites: Courses in Analytical Chemistry and Physical Chemistry. Principles and application of selected analytical methods including electrochemistry, spectroscopy and selected topics of unusual current interest.

CHEM 526 Electro analytical Chemistry. (3 Hours) Prerequisite: Advanced Analytical Chemistry. Discussion of potentiometric, conductometric, polarographic, amperometric, coulometric, controlled potential and stepping analysis and related techniques. Emphasis is also placed on theoretical considerations and applications to studies of chemical and charge transfer equilibria and kinetics.

CHEM 531, 532 Biochemistry. (3 Hours) Prerequisite: One year of Organic Chemistry. The chemical composition of living matter and the chemical mechanics of life processes.

CHML 531, 532 Biochemistry Laboratory. (1 Hour) Prerequisite: Chemistry 531 and 532. Basic purification and characterization techniques in Biochemistry.

CHEM 536 Physical Organic Chemistry. (3 Hours) Prerequisites: Physical Chemistry and Organic Chemistry. A study of organic molecular structure, Woodward Hoffmann Rules, substituents effects, intra- and intermolecular forces, kinetics and stereochemistry.

CHEM 541 Advanced Inorganic Chemistry. (3 Hours) Prerequisite: An undergraduate course in Physical Chemistry. A study of inorganic compounds with the application of Physical Chemistry principles to thermodynamic, kinetic and structural problems.

CHEM 553 Thermodynamics. (3 Hours) Prerequisite: Physical Chemistry. Principles of thermodynamics and their application to chemical and phase equilibria.

CHEM 558 Quantum Chemistry. (3 Hours) Prerequisite: Physical Chemistry. Principles and applications of quantum theory.

CHEM 580 Thesis Research. (Variable 1-6 Hours) Prerequisite: Permission of adviser. Selected topics arranged in consultation with the staff; includes literature, research, and laboratory investigation of a problem.

Doctoral-level Courses in Chemistry

CHEM 711 Seminar (0.5 Hour) Presentations and discussions of current chemistry research topics given by invited speakers, department faculty members and students. Service learning to provide opportunities to students in scientific and social service activities.

CHEM 721 Advanced Instrumental Analysis (3 Hours). Prerequisite: Analytical Chemistry and Physical Chemistry (two semesters). Theoretical principles and laboratory techniques involved in characterization of chemical systems using instrumental methods. This one semester course will present the following topics of interest: absorption and emission spectrometry, mass spectrometry, liquid and gas chromatography, and electrophoresis. A laboratory series on spectro-photometry, fluorometry, atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, FT-IR, gas chromatography-mass spectroscopy, and high performance liquid chromatography are included in this course.

CHEM 723 Advanced Analytical Chemistry (3 Hours) Prerequisite: Analytical Chemistry and Physical Chemistry (two semesters). Quantitative chemical analysis, experimental error, statistics, atomic and molecular spectroscopy, electrochemical analysis and chemical separations. Theories, instrumentation, and applications of chemical analyses using electro analytical methods, absorption, emission, inductively coupled plasma (ICP) – mass spectrometry (MS), and chromatographic methods.

CHEM 726 Electro analytical Chemistry (4 Hours) Prerequisite: Advanced Analytical Chemistry. Principles and application of all modern electrochemical methods such as voltammetrics, chrono-amperometry, spectroelectrochemistry, and thin layer electrochemistry etc. Electrode kinetics and mass transfer are discussed in detail.

CHEM 729 Spectroscopic Methods (3 Hours) Prerequisite: Analytical Chemistry (CHEM 320) and Organic Chemistry (CHEM 242). Using modern spectroscopic methods, mainly Nuclear Magnetic Resonance, Mass Spectrometry, X-Ray Crystallography, and Infrared Spectroscopy for elucidation of chemical compounds. Topics on new developments in modern NMR, X-Ray, MS and IR will be updated and included.

CHEM 731 Advanced Biochemistry (3 Hours) Prerequisite: Biochemistry 431. Protein, enzymology, bioenergetics, chemistry and intermediary metabolism of carbohydrates, chemistry and intermediary metabolism of carbohydrates, lipids, proteins and nucleic acids; Advanced topics on storage, transmission, and expression of genetic information, molecular immunology, membrane transport and hormone action.

CHEM 732 Experimental Biochemistry (3 Hours) Prerequisite: Biochemistry 431. Advanced techniques will be covered for the analysis of cellular function including cell culture and related microscopic techniques, cytotoxicity and cytostatic assays, characterization of kinase activity using immunostaining and electrophoretic methods. This course consists of one-hour lectures and three hours of laboratory work.

CHEM 733 Advanced Molecular Biology (3 Hours) Molecular mechanisms involved in replication, expression and regulation of prokaryotic genes. Topics include: DNA replication, repair, recombination, restriction-modification, recombinant DNA technology, plasmids and transposons, RNA transcription, processing and message splicing.

CHEM 734 Physical Biochemistry (3 Hours) Characterization of macromolecules, hydrodynamic methods, multiple equilibria, macromolecule-ligand interactions.

CHEM 736 Physical Organic Chemistry (3 Hours) Prerequisite: Organic Chemistry (two semesters). A study of organic molecular structure, reactive intermediates, molecular recognition, substituent effects, intra- and intermolecular forces, kinetics, catalysis, stereochemistry, and photochemistry.

CHEM 738 Organic Synthesis (3 Hours) Prerequisite: Organic Chemistry (two semesters). Formation of carbon-carbon and carbon-heteroatom bonds, functionalization and interconversion of functional groups, reactions of organic reagents, protective groups, total synthesis and asymmetric synthesis in organic synthesis.

CHEM 741 Advanced Inorganic Chemistry (3 Hours) Prerequisite: Inorganic Chemistry II (CHEM 340) or its equivalent. A study of symmetry and group theory, bonding and structures of inorganic compounds, coordination chemistry and acid-base chemistry.

CHEM 742 Supramolecular Chemistry (3 Hours) Supramolecular chemistry is the interdisciplinary area of science at the interface of chemistry and biology, which deals with noncovalent bonds between molecules (hosts and guests). Areas of study will include: noncovalent interactions, molecular recognition and its role in biological systems, artificial receptors, self-assembly, supramolecular structures and new materials.

CHEM 743 Structural Inorganic Chemistry (3 Hours) Concepts of the solid state as explored by crystallography, symmetry, polyhedra, and sphere packing, tetrahedral and octahedral structures of inorganic compounds.

CHEM 744 Radiochemistry (3 Hours) A study of natural radioactivity, nuclear systematics and reactions, radioactive decay processes, the transuranium elements, nuclear reactors and nuclear power energy, radiation detections/measurements, radiation biology/medicine and radiations safety security, etc.

CHEM 745 Nuclear Waste Chemistry and Safety (3 Hours) Prerequisites: CHEM 744 or consult the instructor. **C**hemistry of actinides, nuclear fuel cycle and radioactive wastes, advanced separation chemistry, and nuclear safety. It covers radioactive sources, decay, radiation shielding, separation chemistry, and emerging and innovative treatment techniques for fuel reprocessing and radioactive waste treatment. Handling and disposal of nuclear waste, and technical and regulatory aspects of waste management will be reviewed. It will also study nuclear security, medical treatment of radiological injures, cleanup and decontamination after a radiological incident.

CHEM 747 Inorganic Reaction Mechanisms (3 Hours) Prerequisite: Any 700 level course. The topics include mechanism of reactions of certain inorganic compounds, stereochemical changes in complexes, redox reactions, and homogeneous and heterogeneous catalysts.

CHEM 749 Organometallic Chemistry (3 Hours) Prerequisite: Physical Organic Chemistry (CHEM 736) or equivalent. A study of formation, stability, and reactivity of metal-carbon bond of main group and transition metal. It will cover the usage of organometallics in organic synthesis and catalysis.

CHEM 750 Chemistry Teaching Practicum (1 Hour) This course is designed to provide Graduate Teaching Assistants (TAs) with information which can be used to enhance and improve their teaching effectiveness and to learn about teaching approaches that are effective at the college level and to practice and discuss aspects of their teaching assignments.

CHEM 752 Atomic and Molecular Spectroscopy (3 Hours) Prerequisite: Physical Chemistry (two semesters). Concepts and methods of modern atomic and molecular spectroscopy. Subjects covered include electric phenomena, absorption and emission of radiation, atomic spectroscopy, rotational spectroscopy, vibrational spectroscopy, electronic spectroscopy, and magnetic resonance spectroscopy.

CHEM 753 Thermodynamics (3 Hours) Prerequisite: Physical Chemistry (two semesters). Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

CHEM 754 Kinetics (3 Hours) Prerequisite: Physical Chemistry (two semesters). Mechanics of chemical reactions cross-sections, and rate constants. Elastic, inelastic, and rearrangement channels are discussed, using quantum and semi classical techniques.

CHEM 755 Mechanisms of Organic Chemistry (3 Hours) Prerequisite: Organic Chemistry (two semesters). A study of mechanistic aspects of organic reactions included the rate theory, and reaction mechanism, experimental methods and treatment of data.

CHEM 758 Quantum Chemistry (3 Hours) Prerequisite: Physical Chemistry (two semesters). (Computational Chemistry) Important concepts of quantum chemistry at the intermediate level, including angular momentum, perturbation theory, electronic structure of molecules, and radiation matter interaction. Applications may vary from year to year.

CHEM 763 Statistical Mechanics (3 Hours) Prerequisite: Physical Chemistry (two semesters) A study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions, and cluster theory.

CHEM 768 Molecular Quantum Mechanics (3 Hours) Prerequisite: Quantum Chemistry (CHEM 758) or equivalent. Theoretical, algorithmic, and practical aspects of the methods of molecular quantum mechanics and their application to chemical systems. Topics covered include Hartree-Fock theory, perturbation theory, configuration interaction, coupled-cluster theory, and density-function theory.

CHEM 780 Dissertation - (1 - 9 Hours)

CHEM 782 Special Topics in Analytical Chemistry, (3 Hours) Selected topics not covered in regularly scheduled courses, and current research topics in analytical chemistry.

CHEM 783 Special Topics in Biochemistry. (3 Hours) Selected topics not covered in regularly

scheduled courses, and current research topics in biochemistry.

CHEM 784 Special Topics in Organic Chemistry. (3 Hours) A course in a specific area of organic chemistry such as structure determination in organic chemistry, or current research subject not covered in regularly scheduled courses presented to fit the interests of advanced students.

CHEM 785 Special Topics in Inorganic Chemistry. (3 Hours) Topics include subjects of current research in inorganic chemistry, but not covered in regularly scheduled courses.

CHEM 786 Special Topics in Physical Chemistry. (3 Hours) Topics vary from year to year will include subjects such as photochemistry, solid state, surface chemistry, and radiation chemistry.

CHEM 787 Nanoscience and Nanotechnology (3 Hours) Prerequisites: Physical Chemistry (CHEM 342) and Organic Chemistry (CHEM 242). A comprehensive course provides an introduction to the rapidly developing field of Nanoscience and Nanotechnology with special emphasis on general and material chemistry, environmental science, biotechnology, and modeling. The topics include properties of individual nanoparticles, bulk nanostructures, carbon nanotubes, quantum wells, wires, and dots; the tools and methods for measuring these properties; methods for growing and synthesizing nanomaterials; applications in biological materials and the fabrication of nanomachines and devices.

Master level Courses in General Science

SCI 502 General Science for Teachers. (3 Hours) A study of topics in astronomy, chemistry, geology, meteorology and physics.

SCI 507 Earth Science. (3 Hours) An exploratory course dealing with basic concepts in geology, meteorology, and astronomy.

SCIL 507 Earth Science for Teachers Lab. (1 Hour) Laboratory experiments designed to expand subject matter taught in SCI 507.

SCI 508 Cosmology for Non-Scientists. (3 Hours) A study of the structure, makeup origin, and evolution of the universe and objects in it.

SCI 509 Earth History (3 Hours) The course studies history of the continents and oceans and the changes to the atmosphere through time.

SCI 513 Computer Applications in the Teaching of Science. (3 Hours) This course includes computer concepts; programming in the Basic language; building modules for computer assisted instruction and computer aided instruction; problem solving on a microcomputer system.

SCI 515 Earth and Space Science (3 Hours) This course is the study of Earth Science, Geology, and Meteorology.

SCI 516 Physical Science I for Middle School Teachers (3 Hours) This course is the study of properties and reactions of matter.

SCI 517 Physical Science II for Middle School Teachers (3 Hours) This course is the study of Physics, Astronomy and Technology that includes: (in Physics) measurement, force, motion, energy, simple and compound machines, electricity and magnetism, sound, light and heat; (in Astronomy) stars in the night sky, solar system, lunar phases, eclipses, earth seasons, galaxies and universe.

SCI 518 Life Science for Teachers (3 Hours) This course is the study of biochemistry, the cell, genetics, organ systems, natural selection, diversity, ecology and the property and reaction of matter.

SCI 519 Environmental Science and Chemistry for Teachers. (3 Hours)

SCI 520 Methodology for Science Teaching (3 Hours) This course includes exemplary teaching strategies and research-based methods, i.e. Inquiry-based learning, cooperative learning, and the use of technology.

SCI 522 Environmental Science. (3 Hours) A general study of environmental problems created by various kinds of pollution and the effects of man's bio-physical environment.

SCI 523 Seminar in Science (3 Hours) Provides the opportunity to discuss the most pertinent trends in science and to become familiar with current research.

SCI 524 Elements of Astronomy (3 Hours) Survey of solar and stellar systems, with emphasis on the historical and scientific development of astronomy.

SCI 525 Hands-on Activity in Astronomy (3 Hours) This course is support for instructional competency in astronomy in Mississippi.

SCI 551 Hands-on Universe in Mississippi I. (3 Hours) This course integrates mathematics, science and technology in the context of exciting astronomical explorations. This course addresses many of the goals set by the National Council of Teachers of Mathematics and the National Research Council for Math and Science Education.

SCI 563 Problems and Issues in Science. (3 Hours) Content in elementary science; aims and methods of instruction, new curricular developments.

SCI 552 Hands-on Universe in Mississippi II. (3 Hours) Prerequisite: SCI 551. This course integrates mathematics, science and technology in the context of exciting astronomical explorations. This course addresses many of the goals set by the National Council of Teachers of Mathematics and the National Research Council for Math and Science Education.

SCI 580 Science Technology and Environment (3 Hours) An overview of contemporary topics in science and technology. The scientific and technical materials will be covered in detail, then the social consequences of applying or misapplying that knowledge will be examined.

SCI 581 Operation Physics I. (3 Hours) This course is the study of mechanics that includes: measurement, force and motion, simple machines and forces, and fluids.

SCI 582 Operation Physics II. (3 Hours) This course is the study of sound and light that include: measurement, sound, behavior of light, color and vision.

SCI 583 Operation Science for Teachers I. (3 Hours) This course addresses the conceptual understanding and teaching of topics related to physics, space science and meteorology. The curriculum reflects the broader effort to be more inclusive of all the topics that teachers cover in the K12 area. Objectives for the course are correlated to the Mississippi Science Curriculum Structure.

SCI 584 Operation Science for Teachers II. (3 Hours) This course addresses the conceptual understanding and teaching of topics related to physics, space science and meteorology. The curriculum reflects the broader effort to be more inclusive of all the topics that teachers cover in the K12 area. Objectives for the course are correlated to the Mississippi Science Curriculum Structure

SCI 587 Independent Study. (1-3 Hours) For students who are actively working on special projects and consulting with their major professor.

SCI 592-592W Seminar in Meteorology. (3 Hours) Presentation and discussion of special topics and research in meteorology by staff members, students and guest lecturers.

SCI 599 Thesis. (6 Hours) A minimum of 40 hours of research for the thesis must be scheduled. The thesis must show (a) mastery of the techniques of research, and (b) a very distinct contribution to the field under investigation and study.

SCI 601W Seminar in Environmental Science. (3 Hours) Advanced topics of special interest, current research, field trips, demonstrations and guest lecturers.

SCI 602 Construction of Teaching Materials for Secondary Science Instruction. (3 Hours) Special work in models, charts, graphs, photography, electrical apparatus, mechanical equipment, etc.

SCI 603 Special Topics in Science. (3 Hours) Topics of current interest, both theoretical and experimental.

SCI 604 Advanced Methods—Secondary School Science. (3 Hours) Experience with science teaching. Major trends in the new science courses and methodology programs.

SCI 605 Analysis of Science Curriculum. (3 Hours) A critical examination of contemporary and potential science curricular projects.

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING AND INDUSTRIAL SYSTEMS AND TECHNOLOGY

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Dr. P. C. Yuan, Professor

The Department of Civil and Environmental Engineering and Industrial Systems and Technology offers the Master of Science in Education with Technology Education concentration and the Master of Science in Hazardous Materials Management. The Master of Science in Education degree with a concentration in Technology Education is designed to improve the competencies of technology educators, administrators, and other professionals in secondary and post-secondary schools and contemporary technology based workforces. The Master of Hazardous Materials Management is designed to prepare individuals for safety or environmental management manager positions in the safe handling, transporting and managing of hazardous materials and toxic chemicals.

Admission Requirements
Admission to the graduate degree program in Hazardous Materials Management and Technology Education is governed by the regulations of the Graduate School.

Admission Requirements
Admission to the graduate degree program in Hazardous Materials Management and Technology Education is governed by the regulations of the Graduate School.

Hazardous Materials Management

Degree Requirements
The degree options are 30 semester hours plus a thesis; 33 semester hours plus a project; or 36 semester hours of course credit.

Hazardous Materials Management Concentration

Course	Title	Semester Hours
ITHM 520	Introduction of Hazardous Materials Management	3
ITHM 523	Statistics/Data Analysis	3
ITHM 524	Public Issues in Hazardous Materials	3
ITHM525/ BIO 506	Natural Resources and Conservation	3
ITHM 529	Env Toxicology and Risk Assessment	3
	Total Hours	**15**

Emergency Management Concentration

Course	Title	Semester Hours
ITHM 523	Statistics/Data Analysis	3
ITHM 533	Application of GIS in Hazardous Materials Management	3
ITHM 536	Hazards Risk Management	3
ITHM 537	Social and Economic Impacts of Disaster	3
ITHM 538	Nature Hazards and Terrorism	3
ITHM 539	Radiation Safety and Preparedness	3
	Total Hours	**18**

Elective Courses

ITHM 521	System Modeling	3
ITHM 522	Chemistry of Hazardous Materials	3
ITHM 526	Environmental Regulations	3
ITHM 527	Water and Wastewater Treatment	3
ITHM 528	Waste Minimization	3
ITHM 530	Industrial Waste Treatment and Tech.	3
ITHM 532	Emergency Management for Hazardous Materials Management	3
ITHM 534	Independent Study	3
ITHM 535	Occupational Safety and Industrial Hygiene	3
	Total Hours 30, 33, or 36	

*Additional Elective Courses Available

Technology Education

Degree Requirements

The degree options are 30 semester hours plus a thesis; 33 semester hours plus a project; or 36 semester hours of course credit.

Course	Title	Semester Hours
TE 501	Current Literature, Issues and Research	3
TE 504	Laboratory Planning and Management	3
TE 505	History and Philosophy of Technology Educ.	3
TE 512	Administration and Funding	3
TE 513	Instructional Aids	3
	Hours	**15**

Courses in Education

EDFL 514	Elementary Statistics	3
EDFL 515	Methods of Educational Research	3
EDFL 568	Curriculum Methods	3
	Hours	**9**

Elective Courses

TE 500	Seminar/Workshop	3
TE 511	Technical Education	3
TE 515	Career Education	3
TE 516	Curriculum Development	3
TE 521	Problems in Electronics	3
TE 522	Problems in Drafting/Design	3
TE 523	Problems in Metals	3
TE 524	Problems in Woods	3
	Total Hours	**30, 33 or 36**

*Additional Elective courses Available

DESCRIPTION OF COURSES

Hazardous Materials Management

ITHM 500 Graduate Research/Thesis. (1-4 hours) The student is required to select an appropriate topic with approval from advisor and do a presentation.

ITHM 520 Introduction of Hazardous Materials Management. (3 Hours) (For Non-hazardous Materials Management Majors). An introduction to contemporary national problems of air and water pollution, environmental monitoring, toxicology, hazardous waste; general problems of environmental contamination; legal and political aspects of current regulations; general scientific principles applied to the evaluation and control of specific problems.

ITHM 521 System Modeling. (3 Hours) Practical application of simulation to diverse environmental systems including air, land, surface, sub-surface, water systems and also, the hazardous materials management models.

ITHM 522 Chemistry of Hazardous Materials. (3 Hours) This course shows how chemistry can be applied to hazardous materials. The course is designed to introduce and train students' awareness of the unique requirements involved in handling hazardous materials when they are encountered in different situations, thus reducing the loss of lives and property. Prerequisite: Chemistry 135 & 235.

ITHM 523 Statistics/Data Analysis. (3 Hours) This course is designed for the development and maintenance of proficiency in statistical interface. It contains a comprehensive overview of how statistics work in actual cases and how it can be applied in hazardous materials management. Prerequisite: Math 111, CSC 115, & 203.

ITHM 524 Public Issues In Hazardous Materials/Waste. (3 Hours) This course is an overview of the strategies, tactics and techniques regarding environmental affairs, both public and private.

ITHM 525/BIO506 Natural Resources and Conservation. (3 Hours) This course is designed to

give students pertinent information of our natural resources with emphasis on their origin, properties, use, misuse, and conservation practices.

ITHM 526 Environmental Regulations. (3 Hours) A study of Federal Laws and Regulations concerning hazardous materials and wastes. This course will introduce students to laws and regulations in Mississippi and the nation. The course emphasizes how to implement and comply with laws.

ITHM 527 Water and Wastewater Treatment. (3 Hours) Students will be given an overview on waste/wastewater treatment through discussions of various selected topics. The primary focus of these topics will be to introduce students to treatment methods. Prerequisite: BIO 115 and CHEM 142.

ITHM 527 Water and Wastewater Laboratory. (1 hour) This course is the supplementary course of ITHM 527; laboratory activities which develop techniques for testing water and wastewater. This will involve tests for COD, BOD, Alkalinity, Nitrogen, Colonial Count, TCLP and several other tests. Prerequisite: Bio 101, CHEM 135 & 235, and ITHM 401.

ITHM 528 Waste Minimization. (3 Hours) This course is designed to make students aware of the vast number of problems encountered as a result of disposing waste. Also, students will be given lectures on methods of recycling, reuse and reducing our waste.

ITHM 529 Environmental Toxicology and Risk Assessment. (3 Hours) This course will involve studying chemicals and harmful actions of chemicals on biological issues. This will include understanding chemical reactions and interactions of biological organisms. Students will also be introduced to scientific data and methods currently used to access human risk to environmental chemicals.

ITHM 530 Industrial Waste Treatment and Technology. (3 Hours) This course is an advanced course for hazardous waste treatment technology. It includes training in pretreatment of hazardous materials, chemical/physical process, stabilization, recovery processes, final disposal of, and secured landfill stabilization. EPA requirements for each process will be addressed in this class. Prerequisite: ITHM 302.

ITHM 532 Emergency Management for Hazardous Materials. (3 Hours) This is an overview of emergency management concepts for commercial wastes and hazardous materials. It will also discuss emergency management concepts of the four phases of Emergency Management.

ITHM 533 Application of GIS in Hazardous Materials Management. (3 Hours) This course provides a survey of the fundamentals of Geographic Information Systems. The course will provide hands on experience with hardware and software using ArcInfo developed by Environmental System Research Institute.

ITHM 534 Independent Study. (1-3 Hours) This course will provide the student the opportunity to work on special topics of interest with private companies, state and federal agencies related to the hazardous materials management field as approved by the advisor from the department.

***ITHM 535 Occupational Safety & Industrial Hygiene.** (3 Hours) This course provides an introduction to industrial hygiene and to occupational safety and health. It is designed to provide students with basic skills and knowledge on the science and art of identifying, evaluating and controlling workplace hazards.

ITHM 536 (3) Hazards Risk Management. This course will introduce students to the basics models, theories, and concepts that underlie modern emergency management's understanding of hazards and disasters. Students will examine the hazard-scape, using various hazard models, with a focus on hazard mitigation and emergency management issues. The interdependence of physical, social and economic characteristics in determining vulnerability will be considered in past disasters and for future planning. The importance of hazard and risk management in a comprehensive emergency management program will also be presented.

ITHM 537 Introduction to Social and Economic Impact of Disasters (3) this course is to introduce key terms associated with sustainable disaster recovery, describe the individual, social economic and environmental impacts of disasters, and begin to describe the complexities of recovery utilizing case studies

ITHM 538 Nature Hazards and Terrorism (3) this course introduces the students to the various disasters caused by nature, man-made and forms of terrorism. It evaluates how the different levels of governments manage and respond to disasters, governments' policy and continuity plans. There will be a study of different nature and terrorism cases that happened in past years, and discussion and demonstration of "lessons learned and best practices.

ITHM 539 Radiation, Preparedness and Exercises (3) this class introduces the students to the radiation safety, preparedness and emergency response, principles of probabilistic risk assessment. The exercises include case studies, survey, detection and population monitoring.

Technology Education

TE 500 Seminar/Workshop. (3 Hours) Cover factors involved in evaluating the current trends, management, leadership and training for technology based industry, education and other contemporary workforces. Also designed to identify areas were practical training is needed, the specific timeframes of those trainings and proper technology implementation for workforce trainings.

TE 501 Current Literature, Issues and Research. (3 Hours) Exams the current issues that impact industrial and technology education. Focuses on the identification, analysis, and discussion of scholarly research in the fields of technology and education, and how various technologies are utilized in academia and the workforce for proficiency and enhancement.

TE 504 Laboratory Planning and Management. (3 Hours) Designing various industrial education laboratories and facilities. Includes attention to purpose, recommended sizes and other specifications.

TE 505 History and Philosophy of Technology Education. (3 Hours) Provides a comprehensive compilation of technology's philosophy. Also offers an analysis of political, social, cultural, and engineering context affecting the nature of technology along with the influence on technology of historical, metaphysical, and epistemological concerns as it relates to factors involved in developing the trends and leaders in industrial, technology, and career and technical education**.**

TE 511 Technical Education. (3 Hours) Provides a historical overview of career and technical education, and places emphasis on trends, community surveys, curricula, definitions, and needs of post-secondary career and technical education and technology education programs.

TE 512 Administration and Funding. (3 Hours) Identifying current legislation and funding practices concerning industrial education. Function and relationship of directors, supervisors and instructors in all fields of industrial education.

TE 513 Instructional Aids. (3 Hours) Covers the study of instructional aids and training media to properly implement technology means in education. This course focuses on use of multi-media, technology devices, and other technology tools to promote industrial andtechnology proficiency and innovation.

TE 515 Career Education. (3 Hours) Covers aspects and concepts of education focusing on technology and the leadership of career and technical organizations (i.e. career discovery, career counseling, career assessment, etc.). Also identifies current goals and objectives in industrial and career education, and focuses on effective tools that will enhance educational processes and workforce development.

TE 516 Curriculum Development. (3 Hours) Principles and techniques of designing and writing industrial education curricula. Attention will be given to goals, behavioral objectives, designing programs to meet objectives and evaluating results.

TE 521 Problems in Electricity/Electronics (3 Hours) Opportunity to study problems related to the area of electricity/electronics. Problems based on needs of students with approval of the advisor and the Dean of the School.

TE 522 Problems in Drafting. (3 Hours) Opportunity to study problems related to the area of drafting. Problems based on needs of students with approval of the Dean of the School and his advisor.

TE 523 Problems in Metals. (3 Hours) Opportunity to study problems related to the area of metals. Problems based on needs of students with approval of the Dean of the School and his advisor.

TE 524 Problems in Woodworking. (3 Hours) Opportunity to study problems related to the area of woodworking. Problems based on needs of students with approval of the Dean of the School and his adviser.

TE 581W Residential Plumbing. (3 Hours) Residential Plumbing is designed to acquaint the student with the fundamentals of basic residential and commercial plumbing. Much of the class time will be given to hands-on activities. Graduate students in residual plumbing are required to do a research project in air-conditioning and refrigeration.

TE 590 Thesis. (3 Hours) The candidate selects an appropriate topic with approval of adviser and his committee.

TE 599 Independent Research. (1-3 Hours) Opportunities for studying special problems and doing research in the major area. Developed and defined in consultation with the professor.

TE 600 Seminar in Industrial Education. (3 Hours) Seminar in the various fields of industrial and technical education.

TE 601 Selection and Organization of Subject Matter. (3 Hours) Analysis and selection of materials for junior and senior high school, and also, adult industrial technical education.

TE 602 Evaluation of Programs of Industrial and Technical Education. (3 Hours) Evaluation principles and practices in the specialized areas of industrial arts, technical and industrial education.

TE 603 Research in Industrial Education. (3 Hours) Rationale for and methods of research in education. Emphasis is given to the identification of researchable problems and interpretation of research studies in industrial education.

TE 621 Coordination in Occupational Training and Placement Program. (3 Hours) Analysis of objectives and scope of trade and industrial cooperative education program, apprenticeship, and general education work experiences.

TE 622 Developing Occupational Curricula in Two-Year Colleges. (3 Hours) Approaches to occupational curriculum development and course construction in junior colleges. For prospective teachers and administrative personnel.

TE 688 Internship. (variable credit) Supervised graduate internship and externship in various areas of industrial education.

TE 699 Reading and Independent Study. (variable credit) Study on an individual or group basis in industrial education.

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING AND COMPUTER SCIENCE

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Dr. N. Meghanathan, Associate Professor
Dr. T. Pei, Associate Professor
Dr. A. Tanner, Associate Professor
Dr. K. Melpu, Assistant Professor

The Department of Electrical and Computer Engineering and Computer Science offers the Master of Science in Computer Science. The curriculum is geared to 1) provide training for those preparing to enter fields where a substantial working knowledge of computing is required, 2) provide additional training to people already working in the field, and/or 3) prepare students for study at the doctoral level.

Program Objectives

1. To afford students the opportunity for in-depth study of Computer Science concepts and theories.
2. To keep abreast of, and expose students to, state-of-the-art, as well as state-of-the-practice, computer applications and technologies.
3. To engage faculty and students in meaningful computer science research, and computer science applications research and development.
4. To promote professional development and growth of students and faculty.

Admission Requirements

In addition to satisfying the university requirements to enter the graduate school, students must meet other specific requirements in order to be formally admitted to the Department of Electrical and Computer Engineering and Computer Science program. Ideally, students will have a B.S. in Computer Science, or a related field, and at least the equivalent of the following courses:

CSC 118	Programming Fundamentals
CSCL 118	Programming Fundamentals Lab
CSC 119	Object-Oriented Programming
CSCL 119	Object-Oriented Programming Lab
CSC 216	Computer Architecture and Organization
CSC 216L	Computer Architecture and Organization Lab
CSC 225	Discrete Structures
CSC 228	Data Structures and Algorithms
CSC 228L	Data Structures and Algorithms Lab
CSC 325	Operating Systems
EN 212	Digital Logic

ENL 212	Digital Logic Laboratory
BIO 111	General Biology
CHEM 141	General Chemistry
MATH 231	Calculus I
MATH 232	Calculus II
MATH 355	Probability and Statistics
PHY 211	General Physics I
PHY 212	General Physics II

Students who do not have the required background may be admitted as special students. These students must take specified courses to make up deficiencies and no credit toward the degree is awarded for courses prescribed to satisfy entrance requirements.

Degree Requirements
The Department offers courses on a semester basis. Thirty-six credit hours are required for a master's degree. All students are required to pass the departmental Graduate Comprehensive Examination. Students can choose one of the three-degree options: *Thesis*, *Project* or *Course-only* option.

Areas of Emphasis

Networks & Communications	Software Engineering
Computer Architecture	Information Systems
Algorithm Design & Analysis	Artificial Intelligence
Parallel/Distributed Computing	Informatics
Modeling and Simulation	Data Science
Computability & Complexity	Cyber Security

Course Requirements for the Degree Options
All the three-degree options require 36 credits, out of which 12 credits of core courses and 12 credits of major courses are required. The option specific requirements are:
Thesis: Electives (6 credits) and CSC 599 (6 credits)
Project: Electives (9 credits) and CSC 595 (3 credits)
Course-only: Electives (12 credits)

Core Course	Title	Semester Hours
CSC 512	Computer Architecture	3
CSC 515	Data Structures and Algorithm Analysis	3
CSC 518	Operating Systems	3
CSC 519	Principles of Programming Languages	3
	Total Hours	12

Major Courses

Students must choose four major courses for a total of 12 hours

CSC 520	Database Management Systems	3
CSC 524	Comp. Com. Networks and Distributed Processing	3
CSC 525	Wireless Ad hoc Networks	3
CSC 526	Automata Theory	3
CSC 527	Real-time Systems	3
CSC 529	Compiler Construction	3
CSC 530	Theory of Computation	3
CSC 531	Computer Simulation Methods and Models	3
CSC 537	Cloud Computing	3
CSC 541	Cryptography and Network Security	3
CSC 545	Artificial Intelligence	3
CSC 549	Applied Combinatorics and Graph Theory	3
CSC 551	Parallel and Distributed Computing	3
CSC 555	Information Storage and Retrieval	3
CSC 560	Software Engineering	3

ELECTIVES
The elective courses that can be included in the student's degree plan must be approved by the student's Major Advisor and the Department Chair. The elective courses need to be of CSC course prefix and have to be at the 5xx and/or 6xx-levels.

TOTAL REQUIRED FOR DEGREE:
(Thesis, Project or Course-only options) **36**

DESCRIPTION OF COURSES

CSC 505 Computer Mathematics. (3 Hours) Elements of set theory, functions and relations nondecimal numbers, data representation, Boolean algebra. Review of elementary differential and integral calculus with applications to the problems in computer science.

CSC 508 Legal and Economic Issues in Computing. (3 Hours) A presentation of the interactions between users of computers and the law and a consideration of the economic impacts of computers. Includes discussion of computer crime, privacy, electronic fund transfer, and automation.

CSC 509 Computers and Society. (3 Hours) History of computing and technology; place of computers in modern society; the computer and individual; survey of computer applications, legal issues; computers in decision making processes; the computer scientist as a professional; futurist's view of computing; public perception of computers and computer scientists.

CSC 511 Object-Oriented Programming. (3 Hours) Discussion of object-oriented languages. Object-Oriented techniques using the C++ language, classes, objects, constructors, destructors, friend functions, operator overloading, inheritance, multiple inheritance, and polymorphism. Reusability is emphasized.

CSC 512 Computer Architecture. (3 Hours) An advanced introduction to computer design and architecture. Topics include instruction set architecture, RISC computers, control unit design, pipelining, vector processing, memory system architecture, and classification of computers.

CSC 514 Statistical Methods for Research Workers. (3 Hours) Estimation and tests of hypotheses; regression and correlation; analysis of variance; non-parametric statistics; chi-square. SAS programming for data analysis.

CSC 515 Data Structures and Algorithm Analysis. (3 Hours) Mathematical foundations for complexity theory, asymptotic notation, recurrence relations. Strategies for development of algorithms like divide and conquer, greedy, dynamic programming, backtracking. Exposure to some typical and important algorithms in computer science. Introduction to the theory of NP-completeness.

CSC 518 Operating Systems. (3 Hours) Emphasizes the concepts of process communication and synchronization, protection, performance measurement, and evaluation. Problems associated with mutual exclusion and synchronization, concurrent processes, information, process, device, and memory management are examined. Implementation of I/O and interrupt structure is also considered.

CSC 519 Principles of Programming Languages. (3 Hours) Important programming language concepts including, representation of data and sequence control, data abstraction and encapsulation; procedural and non-procedural paradigms: functional, logic, and object-oriented languages; distributed and parallel programming issues.

CSC 520 Database Management Systems. (3 Hours) Introduction to data base concepts including data independence; relations; logical and physical organizations; schema and subschema. Hierarchical, network, and relational models with description of logical and physical data structure representation of the database system. Normalization: first, second, and third normal forms of data relations. Relational algebra and relational calculus; data structures for establishing relations; query functions.

CSC 521 Linear Algebra and Finite Mathematics. (3 Hours) Matrices and determinants; ranks of matrix; inverse of matrix; solving systems of linear equations; bases of a vector space; probability; permutations and combinations; Gaussian vector space; probability; elimination, Gauss-Seidel iteration.

CSC 523 Probability and Statistical Inference. (3 Hours) Elements of probability; combinatorial methods; discrete and continuous distributions; cumulative distribution functions; moment generating functions; distribution associated with normal distributions derived distributions.

CSC 524 Computer Networks and Distributed Processing. (3 Hours) Topologies, media selection, medium access control for local area networks (LANs) including high speed and bridged LANs; circuit switched, ISDN wide area networks (WANs) internetworking issues and standards, 150/051, TCP/IP protocols.

CSC 525 Wireless Ad hoc Networks. (3 Hours) This is a course on the fundamentals, design, architecture, protocols and applications of wireless ad hoc networks. The course will focus on the issues associated with the topology control, MAC layer, network layer, transport layer, security aspects, mobility models and energy consumption models of wireless ad hoc networks. The course will also look at the use of graph theory algorithms for simulating communication protocols in mobile ad hoc networks as well as data gathering protocols in wireless sensor networks.

CSC 526 Automata Theory. (3 Hours) Definition and representation of finite state automata and sequential machines. Equivalence of states and machines, congruence, reduced machines, and analysis and synthesis of machines. Decision problems of finite automata, partitions with the substitution property, generalized and complete machines, probabilistic automata, and other topics.

CSC 527 Real-Time Systems. (3 Hours) An introduction to the problems, concepts, and techniques involved in computer systems, which must interface with external devices. These include process control systems, computer systems embedded within aircraft or automobiles, and graphics systems. The course concentrates on operating system software for these systems.

CSC 529 Compiler Construction. (3 Hours) An introduction to the major methods used in compiler implementation. The parsing methods of LL (k) and LR (k) are covered as well as finite state methods for lexical analysis, symbol table construction, internal forms for a program, run time storage management for block structured languages, and an introduction to code optimization.

CSC 530 Theory of Computation. (3 Hours) A survey of formal models for computation. Includes Turing Machines, partial recursive functions, recursive and recursively enumerable sets, abstract complexity theory, program schemes, and concrete complexity.

CSC 531 Computer Simulation Methods and Models. (3 Hours) A study and construction of discrete-system simulation models. Use of discrete-system simulation language (GPSS/H), advance programming techniques, random number generation, generation of various random variate, and statistical validation procedure.

CSC 532 Numerical Methods. (3 Hours) Applying principles and techniques for computing methods. Solution of linear and nonlinear equations. Matrix methods for systems of equations. Polynomial approximation. Numerical integration. Solution of ordinary differential equations using various methods.

CSC 533 Distributed Database System. (3 Hours) Prerequisites: CSC 520, 524. A consideration of the problems and opportunities inherent in distributed database on a networked computer system. Includes file allocation; directory systems; deadlock detection and prevention; synchronization; query optimization; and fault tolerance.

CSC 535 Information System Analysis and Design. (3 Hours) Prerequisite: 519. A practical guide to information systems programming and design. Theories relating to module design, coupling, and module strength are discussed. Techniques for reducing a system's complexity are emphasized. The topics are oriented toward the experienced programmer or systems analyst.

CSC 537 Cloud Computing. (3 Hours) The course will present the state of the art in cloud computing technologies and applications as well as providing hands-on project opportunities and experiment with different technologies. Topics will include: telecommunications needs; architectural models for cloud computing; cloud computing platforms and services; security, privacy, and trust management; resource allocation and quality of service; cloud economics and business models; pricing and risk management; interoperability and internetworking; legal issues; and novel applications.

CSC 539 Special Topics in Computer Science. (Variable 1-9 Hours) Prerequisite: Consent of instructor. Topics and problems of information systems that are of practical importance and current interest. New developments in system concepts, techniques, and equipment.

CSC 540 Microcomputer Local Area Networks. (3 Hours) Prerequisites: 518. This course describes various criteria for selecting and implementing local area networks (LANs) consisting of microcomputers.

CSC 541 Cryptography and Network Security. (3 Hours) This course will focus on graduate-level topics in cryptography and network security, including: Symmetric Key and Public Key encryption algorithms, Digital Signatures, Certificates, Cryptanalysis, Key management and distribution, Classical network attacks and their solutions, User authentication protocols, Transport-level security, Wireless network security, E-mail security, Web security, IP security, Distributed system security, Firewalls and Intrusion detection systems.

CSC 545 Artificial Intelligence. (3 Hours) Efficient and intelligent search techniques. Knowledge representation e.g., logic, and semantic nets. Reasoning techniques including reasoning under uncertainty, e.g., fuzzy reasoning. Exposure to different artificial intelligence systems like planning and learning (including neural networks).

CSC 549 Applied Combinatorics and Graph Theory. (3 Hours) A study of combinatorial and graphical techniques for complexity analysis including generating functions, recurrence relations, Polyal's theory of counting, planar directed graphs, and NP-complete problems. Applications of the techniques to the analysis of algorithms in graph theory, sorting, and searching.

CSC 551 Parallel and Distributed Computing. (3 Hours) Prerequisite: CSC 512 Computer Architecture or approval of Department. The course introduces the concepts and design of parallel and distributed computing systems. Topics covered include: Data versus control parallelism (SIMD/Vector, Pipelines, MIMD, Multi-core, GPU); Shared versus distributed memory (SMP and NUMA), Message passing Interface (MPI) and Topologies; Parallel and distributed algorithms: Paradigms, Models and Complexity, Scheduling, Synchronization, Deadlock detection, Fault tolerance and Load balancing.

CSC 552 Applied Programming. (3 Hours) Prerequisite: Department and advisor approval. This course focuses on the fundamentals of computing and is geared toward non-CS majors going into computational sciences. The course will cover key concepts of data structures, data manipulation, algorithms and efficiency, and how they apply to the various application domains specific to computational fields. The course will also provide an introduction to Python for computational sciences. Topics include: an introduction to computational complexity, data structures (arrays, lists, stacks, queues, trees, and graphs), elementary algorithms and their complexity.

CSC 555 Information Storage and Retrieval. (3 Hours) Advanced data structures, databases, and processing systems for access and maintenance. For explicitly structured data, interactions among these structures, access patterns and design of processing/access systems. Data administration, processing system life cycle, system security.

CSC 560 Software Engineering. (3 Hours) Formal approach to techniques and software design and development. Software cycle encompassed from initial ideas through code design and implementation with emphasis on object-oriented design techniques will be included. Software testing and maintenance will be discussed.

CSC 571 Programming for Big Data. (3 Hours) The course will expose students to three programming paradigms for big data analytics to cover the three Vs: Velocity, Volume, and Variety. The course will focus on design and development of programs based on the: (1) Supervised and unsupervised machine learning algorithms to perform predictive analytics of Big Data and implement them using a high-level interpreted language such as Octave; (2) Map-reduce parallel programming paradigm for selected data-intensive computational problems; (3) Functional programming paradigm using languages such as OCaml to analyze big data in a recursive fashion. In addition, the course will enable students to be able to configure a distributed file system based on the Hadoop architecture for reliable shared storage and develop programs that interface with it, as well as manage large datasets using SQL-like access to unstructured data (Hive) and NoSQL storage solutions (HBase).

CSC 573 Modeling and Simulation of Complex Systems. (3 Hours) The course focuses on the application of modeling and simulation principles to large-scale non-linear complex systems with interconnected parts (like a biological cell, economy or an ecological system). Topics covered include: non-linear differential equations, networks, stochastic models, cellular automata, agent-based modeling and swarm-like systems.

CSC 582 Social Network Analysis. (3 Hours) This course will cover the structure and analysis of large social networks on models and algorithms that abstract their properties. Topics covered include: Nodes, edges, and network measures, structure, and visualization and tools, the tie strength of networks, trust in social media, analyzing and classifying user roles, attributes and behavior, link prediction and entity resolution, epidemic models, location-based social media analysis, social sharing and filtering, aggregation and data mining, and network strategies for the individual and for the government.

CSC 595 Information Systems Development Project. (Variable 1-6 Hours) Prerequisites: Pass comprehensive examination and consent of advisor. Provide the student with the experience in analyzing, designing, implementing, and evaluating information systems. Students are assigned one or more system development projects. The project involves part or all of the system development cycle.

CSC 599 Thesis Research. (Variable 1-6 Hours) Prerequisites: Pass comprehensive examination and consent of advisor. An independent study course for the preparation of a Master's thesis.

CSC 601 Computing Algorithms. (3 Hours) Prerequisite: CSC 515 Data Structures and Algorithm Analysis or CSC 323 Algorithm Design and Analysis or department approval. The course focuses on algorithms of different design strategies, and the mathematical concepts used in describing the complexity of an algorithm. Topics covered include: Asymptotic notations; Time complexity analysis of iterative and recursive algorithms; design strategies like Brute force, Divide and Conquer, Transform and Conquer, Greedy and Dynamic programming; Space-time tradeoffs in algorithms and NP-completeness - Heuristics and Approximation algorithms. The course will also cover graph theory algorithms and string matching algorithms with respect to the application of the above design strategies for specific problems.

CSC 620 Database Management Systems. (3 Hours) This course is designed for non-computer science majors entering the Ph.D. in Computational and Data Enabled Sciences and Engineering. It introduces students to the concepts and theories of database systems, necessary in the CDS&E fields. Topics include: information models and systems; the database environment; data modeling; conceptual modeling using the entity-relationship approach and mapping to relational tables; the relational model including the relational data structure, integrity rules, relational algebra and relational calculus; normalization; data definition and data manipulation in SQL; conceptual, logical, and physical database design; security; transaction management; query processing; and advanced topics in database systems, and how this applies to computational and data enabled sciences and engineering.

CSC 621 Machine Learning. (3 Hours) Pre-requisite: CSC 601 Computing Algorithms or CSC 515 Data Structures and Algorithm Analysis or CSC 323 Algorithm Design and Analysis. This course will deal enable students to understand the underlying algorithms used in various learning systems. Topics covered include: Inductive classification, Decision-tree learning, Ensembles, Experimental evaluation, Computational learning theory, Rule learning, Neural network learning, Support vector machines, Bayesian learning, Instance-based learning and Text categorization.

CSC 630 Computability and Complexity. (3 Hours) This course will cover advanced topics in computability and complexity theory. Computability topics covered include: Church-Turing Thesis, Decidability, Reducibility, Recursion Theorem and Decidability of logical theories. Complexity topics covered include: Time Complexity (P, NP, NP-Completeness), Space Complexity (Savitch's theorem, PSPACE, NL-Completeness), Intractability, Probabilistic algorithms and Alternation.

CSC 634 Big Data Mining. (3 Hours) Pre-requisite: CSC 621 Machine Learning or department approval. This course will focus on data mining of very large amounts of data that is so large enough not to fit in main memory, characteristic of data retrieved from the web. Topics to be covered include: Distributed file systems and Map Reduce, Similarity search techniques, Real-time data-stream processing algorithms, Technology of search engines (PageRank, Link-spam detection, hubs-and-authorities approach) and Frequent-item set mining. The course will also expose students to algorithms for clustering very large, high-dimensional datasets.

CSC 635 Big Data for Cyber Security. (3 Hours) Pre-requisite: CSC 621 Machine Learning or department approval. This course will focus on data-driven approaches to detect threats and attacks that originate from diverse channels at a rapid rate, necessitating the need for scalable distributed monitoring and cross-relation with a substantial amount of contextual information. The course will cover various anomaly-based Big Data analytics solutions for Cyber Security.

CSC 641 Network Science. (3 Hours) Pre-requisite: CSC 601 Computing Algorithms or CSC 515 Data Structures and Algorithm Analysis or CSC 323 Algorithm Design and Analysis. Topics covered include the measurement and structure of networks, methods for analyzing network data, including methods developed in physics, statistics, and sociology, graph theory, computer algorithms, mathematical models of networks, including random graph models and generative models, and theories of dynamical processes taking place on networks.

CSC 651 Foundations of Programming and Computation Systems. (3 Hours) This course will focus on graduate-level central concepts in modern programming languages, impact on software development, language design trade-offs, and implementation considerations. Functional, imperative, and object-oriented paradigms. Formal semantic methods and program analysis. Modern type systems, higher order functions and closures, exceptions and continuations. Modularity, object-oriented languages, and concurrency. Runtime support for language

features, interoperability, and security issues. Prerequisite: experience in any object-oriented language.

CSC 653 Large Scale Computing. (3 Hours) Prerequisite: CSC 551 Parallel and Distributed Computing. The course will focus on large-scale modeling techniques, algorithms and computational techniques for Big Data computing. Large-scale modeling techniques covered will include linear models, graphical models, matrix and tensor factorizations, clustering, and latent factor models. Algorithmic topics include sketching, fast n-body problems, random projections and hashing, large-scale online learning, and parallel learning. The computational techniques covered in this course will provide a basic foundation in large-scale programming, ranging from the basic "parfor" to parallel abstractions, such as MapReduce (Hadoop) and GraphLab.

CSC 661 Software Engineering for Computational Applications. (3 Hours) This course focuses on computational software engineering for engineering and scientific applications. Topics include Characteristics of computational software, Development and maintenance activities, Requirement engineering for computational software, Problem analysis and solution design tools, Component reuse, Software reliability, and Computational software validation and verification.

CSC 663 High Performance Scientific Computing. (3 Hours) The course will focus on design of high performance parallel programs for scientific computing. Topics covered include: Single-processor performance, memory hierarchy and pipelines; parallel system organization; message passing and MPI programming; Problem decomposition, graph partitioning, load balancing, Shared memory, CUDA, GPU and OpenMP programming.

DEPARTMENT OF MATHEMATICS AND STATISTICAL SCIENCES

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The Department of Mathematics and Statistical Sciences offers a doctoral degree concentration in computational mathematics and statistical sciences through the College of Science, Engineering and Technology's Ph.D. program in Computational Data-Enabled Sciences and Engineering (CDS&E). The Department also offers programs leading to the MST degree in mathematics designed for persons who wish additional preparation for mathematics teaching or mathematics supervision and the MS degree in Pure or Applied Mathematics for students who seek careers in academia, government, industry or the business sector. The programs are designed for persons with adequate background in undergraduate mathematics beyond the calculus sequence.

Program Mission

The Department of Mathematics and Statistical Sciences aims to equip its graduate with the necessary advanced mathematics and statistical knowledge and skills that prepares them to find solutions to mathematics or statistics problems arising in other academic fields and in areas outside the normal academic setting and to use this knowledge to solve society problems of challenge. The program aims for national and international distinction in preparing mathematics students for a spectrum of careers including academic and non-academic employment.

Program Objectives

1. To provide quality mathematics training at the doctoral and master's degree level.
2. To provide a learning and research friendly environment for all students.
3. To prepare students to recognize opportunities for advancing mathematics or statistical ideas arising in other fields.
4. To increase the pool of mathematicians seeking academic and non-academic employment.

Transfer of Credits

A course for which transfer credit is sought must have been completed with a grade of "B" or better. Departmental approval is required.

Time Limit

Students with adequate mathematics preparation at the undergraduate level will normally take two years to

complete any of the Master's degree programs and a minimum of five years to complete the doctoral program. However, all students must complete their programs within eight years of starting coursework at Jackson State University or elsewhere.

Degree Programs
CDS&E Ph.D. Program in Computational Mathematics and Statistical Sciences Track

The CDS&E Ph.D. with a concentration in Computational Mathematics and Statistical Sciences Program is an interdisciplinary program designed to ensure that the student acquires knowledge in a broad spectrum of the mathematics and statistical sciences through quantitative exploration of data. The Ph.D. in CDS&E programs of study are structured to reflect the belief that a student in the program should not only be proficient in a specialized track, but also understand how it relates to other academic fields and big data and be able to recognize opportunities for developing new ideas of the track and solve real-world problems. As a result, the Ph.D. graduate in computational mathematics and statistical sciences is equipped with all necessary tools and skills to recognize opportunities for developing and advancing mathematics and statistical ideas arising from other academic fields and for work outside of the traditional mathematics and statistics academic setting. In addition to opportunities for consulting experience through the Laboratory for Interdisciplinary Statistical Analysis through Quantitative Exploration of Data (LISA-QED), students in the Ph.D. track may have opportunities for participation on research projects through other facilities on campus designed for Computational and Quantitative Simulations and make presentations at professional CDS&E conferences.

Admission Requirements
To be considered for admission, the following requirements should be met:

- Applicants must have completed the Graduate Application for Admission.
- Applicants must have provided official copies of transcripts from all colleges/universities attended.
- The applicant must have a Bachelor's or Master's degree from an accredited college or university in STEM field or related fields, and
- A minimum GPA of 3.00 (on a 4.00 scale) on the highest degree earned.
- A satisfactory TOEFL score for international students whose native language is not English.
- Three letters of recommendation from three professors knowledgeable of the applicant's professional academic ability, job experiences, and leadership potential.
- An official score on the Graduate Record Examination (GRE).
- A statement of purpose.

Degree Requirements
Common Core = 12 credit hours
Track Requirement = 12 credit hours
Track electives = 24 credit hours
Dissertation = 24 credit hours

Please refer to College of Science, Engineering and Technology section of the catalog for all the details regarding the CDS&E Ph.D. degree completion. Students are advised to follow the guidelines given by the Division of Graduate Studies for the completion of the Doctorate degree.

Ph.D. Examination Procedures

- Comprehensive Examination
- Preliminary Examination
- The Dissertation (Thesis)
- The Dissertation Defense

Comprehensive Examination
In order to ensure that the skills and basic knowledge have been acquired to carry out the research necessary for the dissertation, the student must demonstrate competence in four subject areas chosen from the set of the required Ph.D. courses. Competence is demonstrated by passing a written comprehensive examination in each of the four subject areas. One of the four examinations is waived by completing a sequence of two courses from the list of elective courses with a grade of B or better. Completion of the required courses should be adequate preparation for the comprehensive examination. Comprehensive examinations will be administered at the beginning of the Fall Semester and once during summer. Satisfactory progress toward the degree is demonstrated by passing the comprehensive examination by the end of the third full academic year of Ph.D. work. The comprehensive examination may be repeated.

Preliminary Examinations
After the comprehensive examination has been passed, and all required course work completed, the student request the preliminary examination for admission to degree candidacy. The preliminary examination is an oral examination on the core and required courses for the computational mathematics and statistical sciences track. It is designed to test the student's general knowledge of CDS&E with a focus on computational mathematics and statistical sciences. The student's doctoral committee will give the examination. A pass of fail will be determined by a simple majority vote of the committee.

The Dissertation
After the preliminary examination has been passed, the student's doctoral committee will be reconstituted to form the dissertation committee. The student and the major professor of the doctoral committee will select

the student's dissertation committee, subject to the approval of the departmental Graduate Coordinating Committee. The dissertation committee will consist of at least five graduate faculty members, including a major professor and at least three additional graduate faculty members from the other CDS&E tracks. The primary responsibility of the committee will be to supervise the student's research and writing of a dissertation in the area of specialization, and its members should be chosen with this mission in mind.

In the early stages of the research effort, the student will make a formal dissertation proposal to the dissertation committee. The dissertation will be an original work that makes a significant contribution to the student's area of specialization.
A person from outside the Department of Mathematics and Statistical Sciences who has expertise in the dissertation area will be enlisted by the student and his/her committee to serve as an external examiner for the dissertation. This person will read the dissertation and submit written comments regarding its quality and significance to the student's committee.

Dissertation Defense
After completing the dissertation, the student's committee will schedule the final dissertation defense for the student. This is an oral defense of the dissertation open to the public.
After consultation with the Graduate Coordinator/Department Chair, the major professor will publicize the time and place of the dissertation defense a week prior to the scheduled defense date.
A pass or fail on the defense will be determined by a simple majority vote of the student's committee. In making its decision, the committee will give due consideration to the external examiner's assessment of the dissertation.

Master's Degrees

The M.S. degree is research oriented and a Thesis is required for graduation. The M.S.T. degree, in general, can be completed with only course work; a Thesis or Project is optional. However, all of the programs are designed to meet academic requirements for students who are interested in seeking degrees beyond the master or specialist level. The M.S.T. degree would lead to a Class "AA" Teaching Certificate for students who hold the Class "A" Teaching Certificate. A student can also receive the M.S.T. degree without seeking the Class "AA" Teaching Certificate. The coursework requirement for this option is the same with those holding the Class "A" Teaching Certificate.

Admissions Requirements
Admission to any of the Master's degree program in mathematics requires at least 15 semester hours of undergraduate mathematics above the regular calculus sequence and the fulfillment of the admission requirement into graduate studies at Jackson State University, which is an earned Bachelor's degree with a cumulative GPA of at least 3.0 on the 4.0 scale in all undergraduate courses taken at a regional accredited degree granting institution. GRE is not required for admission into any of the Master's degree programs. However, students who are seeking to pursue the doctoral degree are encouraged to take the GRE exams, general and subject area, to increase their chances for competitive admission and financial assistance. These exams can be taken while students are taking courses or after they have completed all coursework.

Master of Science in Mathematics

The departments offers programs leading to the M.S. degree in Pure or Applied Mathematics for students who plan on pursuing the doctoral degree or wish to seek careers in college or university teaching, government, industry and the business sector. The programs are designed for persons with adequate background in undergraduate mathematics beyond the calculus sequence.

To receive the M.S. degree a student must be in residence at Jackson State University for at least one semester, complete all degree requirements and must take and pass the Graduate English Competency Exam. If a student's GPA upon completion of all coursework is below 3.33, then such a student is required to take and score at least 70% on a comprehensive exit exam given by the Department.

The requirements for the M.S. degree are:

1. Thirty six (36) hours are required with a thesis, or thirty three (33) hours with a project, or thirty six (36) hours of course work with a score of 70% on an area comprehensive exam.
2. A "B" average with no more than one "C" grade is required for graduation.
3. Pass the Graduate English Competency Exam

Required Courses

Course	Title	Semester Hours
Math 513	Modern Linear Algebra 1	3
Math 511	Modern Algebra 1	3
Math 531	Real Analysis 1	3
Math 541	Complex Analysis 1	3
Math 551	Introduction to General Topology 1	3
Math 561	Probability and Statistics I	3
Math 599	Thesis	3
	Total Hours	24

The student will fulfill the remaining 12 hours from mathematics electives drawn from a list of pure or applied mathematics courses to match his/her area of concentration. Courses are offered each semester to match each enrolled student's interest. In consultation with an advisor and the Chairperson of the Department, a student must develop a study plan and select sufficient

electives from departmental courses to complete degree requirements with a concentration in either pure or applied mathematics. See the list of departmental courses below. A typical study plan for a student with a concentration in applied mathematics who is seeking to pursue a doctoral degree would look like this:

Coursework for Year One

Fall Semester

Math 511	Modern Algebra I
Math 513	Modern Linear Algebra I
Math 531	Real Analysis I

Spring Semester

Math 577	Ordinary Differential Equations with Applications
Math 579	Partial Differential Equations with Applications Math
Math 541	Complex Analysis I

Summer Sessions

Math 599	Thesis

Coursework for Year Two

Fall Semester

Math 551	Introduction to General Topology I
Math 542	Complex Analysis 11
Math 532	Real Analysis II
Math 580	Partial Differential Equations 11 or
Math 599	Thesis
	Extra Coursework and Thesis Defense

Spring Semester

Math 537	Introduction to Functional Analysis
Math 547	Integral Equations
Take the GRE	both General and Subject area tests
Math 599	Thesis

Master of Science in Teaching
Mathematics and Science Education

The Mathematics and Science Education degree is a The Mathematics and Science Education degree is a master-level degree offered within the College of Science, Engineering, and Technology under the direction of the Department of Mathematics and in cooperation with the College of Education and Human Development. There are three areas of concentration under the MST. A student can take coursework with concentrations in biology, mathematics or earth sciences. The concentration in mathematics is designed for persons with an adequate background in mathematics and who wish additional preparation for mathematics teaching or mathematics supervision.

The requirements for the M.S.T. degree with a concentration in mathematics are:

The Mathematics and Science and Education degree offers concentrations in one of three areas: biology, mathematics or earth science. Coursework specific to biology and earth science are found within their respective department degree program requirements.

1. Thirty six (36) hours are required with a thesis; i.e., ten (10) courses and six (6) hours for a thesis.
2. Thirty six (36) hours are required with a project; i.e., eleven (11) courses and three (3) hours for a project.
3. Thirty six (36) hours are required if neither a thesis nor a project is done. All credit hours are completed by coursework.
4. A "B" average with no more than one "C" grade is required for graduation, if a student has two "C" grades, then the student must earn an "A" grade in an additional course.
5. A maximum of eighteen (18) hours can be counted from education classes.
6. Pass the Graduate English Competency Exam

Core Educational

Course	Title	Semester Hours
EDFL 511	History and Philosophy of Education (R)	3
EDFL 515	Methods of Educational Research (R)	3
EDFL 514	Elementary Statistics (R*)	3
EDFL 568	Curriculum Methods (R*)	3
	Total Hours	12

(R) - Required
(R*) - Required for students without an undergraduate Statistics course and it is a prerequisite for EDFL 515.

Required Mathematics Courses

Course	Title	Semester Hours
Math 501	Topics in Geometry	3
Math 506	Basic Concepts for Teachers I	3
Math 510	Topics and Issues in Mathematics	3
Math 513	Linear Algebra 1	3
Math 511	Abstract Algebra 1	3
Math 531	Real Analysis 1	3
	Total Hours	18

Any substitute for the above courses must seek the Department of Mathematics and Statistical Sciences' approval.

Requirements for Option Choices

Option 1: Math 590 Thesis 6
Option 2: Math 584 Independent Study (Project) 3
and a Three hour course selected from List I,
Or
Option 3: Three hours selected from List I
and three hours selected from List II or List III.

Total number of hours = 36

A student may concentrate in Applied Mathematics by taking the four (4) elective courses from: Math 514, 537, 541, 542, 561, 562, 565, 566, 577, 579, 580, 581, 582, CSC 511, 512, 515, 518, 531 and 561 or Foundation of Mathematics by taking from: Math 503, 512, 535, 541, 542, CSC 511, 512, 515, 518, 531 and 561.

List I

1. Math 503 Foundations of Mathematics I
2. Math 504 Foundations of Mathematics II
3. Math 512 Modern Algebra II
4. Math 514 Modern Linear Algebra II
5. Math 532 Real Analysis II
6. Math 541 Complex Analysis I
7. Math 542 Complex Analysis II
8. Math 561 Probability and Statistics I
9. Math 562 Probability and Statistics II
10. Math 551 Introduction to General Topology I
11. Math 552 Introduction to General Topology II
12. Math 581 Number Theory I
13. Math 582 Number Theory II

List II

14. Math 505 Mathematics for Secondary Teachers
15. Math 507 Mathematics Concepts for Teachers II
16. Math 509 Mathematical Structures
17. Math 519 Topics in Mathematics Education I
18. Math 520 Topics in Mathematics Education II

List III

19. CSC 511 Computers and Programming
20. CSC 512 Introduction to Computer Systems and Organization
21. CSC 515 Data Structures and File Management
22. CSC 518 Principles of Operating Systems
23. CSC 531 Computer Simulation Methods and Models
24. CSC 561 Probability and Statistical Inference I

Master's Degree in any of the Education Areas with a Concentration in Mathematics Requirements

Students in any of the Master's Degree Programs in the College of Education and Human Development who wish to seek a concentration in Mathematics must meet the following requirements:

1. Satisfaction of the admission requirement in the mathematics graduate programs of three advanced mathematics courses beyond the calculus sequence, or completion of an undergraduate degree program at a regionally accredited institution in Elementary or Secondary Education with a concentration in mathematics.
2. Meet the 18 credit hours requirement in Mathematics as follows:
3. Nine (9) credit hours must be taken from the following courses with a cumulative average of at least a "B": Math 513 -Linear Algebra 1, Math 511 - Abstract Algebra 1, Math 531 - Real Analysis I or Math 541 -Complex Analysis 1.
4. The remaining nine (9) hours can be taken in any combination of the graduate level mathematics education courses and the general mathematics courses.

DESCRIPTION OF COURSES

Mathematics Education Courses

MATH 501 Topics in Geometry. (3 Hours) Prerequisite: Approval of department. A survey of geometries and their structures. Emphasis is on both synthetic and analytic methods.

MATH 502 Topics in Algebra. (3 Hours) Prerequisite: Approval of department. An amalgamation of classical and modern theory, stressing the synthesis of ideas in areas from equation solvability, special algebraic forms (permutations, combinations, arrangements, binomial and multinomial theorems, partial fractions, progressions, groups, rings, domains of integrity, and ideas of interest).

MATH 503-504 Foundations of Mathematics I-II (3-3 Hours): The fundamental elements of set theory and finite mathematical structures; cardinals and ordinals; logical deduction, elements of probability; vectors and matrices, linear programming, theory of games and applications.

MATH 505 Mathematics for Secondary Teachers (3 Hours): Prerequisite: Approval of department. The basis of the content, philosophy and methodology employed in the teaching of secondary school mathematics is of prime interest here.

MATH 506-507 Mathematics Concepts for Teachers I-II (3-3 Hours): Prerequisite: Approval of department. Higher mathematics for teachers, reviewing the fundamental areas of algebra, geometry and analysis, with stress on rigor and validity of ideas.

MATH 510 Topics and Issues in Mathematics (3 Hours): This course is designed for in-service teachers who are interested in the renewal of teaching licenses and the pursuit of graduate studies in the teaching of mathematics. Emphasis is on individualized research dealing with the stages of development of mathematics, new trends in the teaching of mathematics, and the exploration of teaching theories resulting from the work of experimental psychologists such as Piaget, Aushel and Bruner. Because of the individualized nature of the course, students with diverse backgrounds in mathematics can be accommodated.

Courses for all Graduate Mathematics and CDS&E Majors

MATH 511-512 Modern Algebra I-II (3-3 Hours) Groups, (homomorphism), rings, integral domains, modules and fields, elementary linear algebra, number theory.

MATH 513-514 Modern Linear Algebra I-II (3-3 Hours) Vector spaces, matrices, linear transformations,

determinants and linear equations. Selected topics on eigenvalues, canonical forms, inner products, inner product spaces, bilinear and quadratic forms.

MATH 515-516 Advanced Modern Algebra III-IV (3-3 Hours) Prerequisite: Mathematics 512. Special topics in groups, rings and fields, factorization theory, extensions of rings and fields, modules, elementary theory of fields.

MATH 521-522 Modern Geometry I-II (3-3 Hours): Prerequisite: Mathematics 511, concurrent enrollment or approval of department. Historical development; sets and projective planes and geometries; vectors, transformations, axiomatic affine, projective and plane geometry.

MATH 523-524 Modern Geometry III-IV (3-3 Hours) Prerequisite: Mathematics 523 or approval of department. Motions and transformations, projective and topological transformations, projective plane, analytic projective geometry; absolute, ordered, affine and hyperbolic geometries; elementary differential geometry, topology of surfaces.

MATH 525-526 Introduction to Differential Geometry I-II (3-3 Hours): Prerequisite: Mathematics 523 or approval of department. Curves and surfaces in three dimensions by classical methods, introduction to corresponding problems in n-dimensions involving tensor methods.

MATH 527-528 Projective Geometry I-II. (3-3 Hours) Prerequisite: Mathematics 512 or approval of department. The projective plane, polarities and conic sections, affine geometry, projective metrics, non-Euclidean Geometry, spatial geometry.

MATH 529-530 Systems Analysis I-II. (3-3 Hours) Prerequisite: Approval of department. An analysis of the numerical and abstract systems of mensuration. Stress is placed on the metric and English systems, conversion analysis and other systems of interest.

MATH 531-532 Real Analysis I-II. (3-3 Hours) Prerequisite: Math 511 or approval of department. Metric spaces, regulated functions and integrals; integrals of Riemann and Lebesgue; trigonometrical and Fourier series; differentiation and Stieltjes Integrals.

MATH 533-534 Advanced Analysis I-II. (3-3 Hours) Prerequisite: Mathematics 532 or approval of department. Further treatment of limits, continuity, differentiability and integrability of functions of one and more variables. Infinite series and products, power and trigonometric series; selected topics.

MATH 535-536 Introduction to Measure and Integration I-II. (3-3 Hours) Prerequisite: Mathematics 531 or approval of department. Lebesgue measure of linear sets, measurable functions, definite integral, convergence, integration and differentiation, spaces of functions, orthogonal expansions, multiple integrals and the Stieltjes Integral.

MATH 537-538 Introduction to Functional Analysis I-II. (3-3 Hours) Prerequisites: Mathematics 512, 531, or approval of department. Fundamentals of the theory of vector spaces; Banach spaces; Hilbert spaces. Linear functional and operators in such spaces; spectral resolution of operators, applications.

MATH 539-540 Introduction to Infinite Series I-II. (3-3 Hours) Prerequisites: Mathematics 511 and approval of department. Complex numbers, sets and functions; limits and continuity; analytic functions of a complex variable, elementary functions; integration; power and Laurent series, calculus of residues, conformal representation, special topics.

MATH 541-542 Complex Analysis I-II. (3-3 Hours) Complex numbers, sets and functions; limits and continuity; analytic functions of a complex variable, elementary functions; integration; power and Laurent series, calculus of residues, conformal representation, special topics.

MATH 544 Introduction to Entire Functions. (3 Hours) Prerequisite: Mathematics 541. Entire functions, maximum absolute value and order, zeroes of entire functions, fundamental theorem of algebra, Picard's Little Theorem, algebraic relationships and addition theorem; special theorems and functions.

MATH 545 Laplace Transforms. (3 Hours) Prerequisites: Math 534 and approval of department. The Stieltjes Integral; fundamental formulae; moment problem, Tauberian theorems, bilateral Laplace Transform, inversion and representation problems, the Stieltjes Transform.

MATH 546 Special Functions. (3 Hours) Prerequisites: Math 535 and approval of department. Infinite products, Gamma and Beta functions, series, polynomials, functions, relations and sets of analysis and differential equations.

MATH 547-548 Integral Equations I-II. (3-3 Hours) Prerequisites: Math 534, 542, and approval of department. Theory of Fredholm and Volterra equations; Hilbert-Schmidt theory; singular integral equations and some applications.

MATH 549-550 Methods In Applied Mathematics I-II. (3-3 Hours) Prerequisite: Approval of department. Elements of linear algebra; applications to systems of linear variables; function spaces; tensor analysis, applications to geometry, electromagnetic theory, Lagrangian and Hamiltonian formulations of mechanics; other topics of interest.

MATH 551-552 Introduction to General Topology I-II. (3-3 Hours) Prerequisites: Mathematics 223 and approval of department. Elementary set theory, ordinals and cardinals; topological spaces; cartesian products; connectedness; special topologies; separation axioms; covering axioms, metric spaces; convergence; compactness; function spaces; spaces of continuous functions and complete spaces; homotopy; maps into spheres; topology of En; homotopy type; introduction to algebraic topological ideas.

MATH 553-554 Introductory Algebraic Topology I-II. (3-3 Hours) Prerequisites: Mathematics 552 and approval of department. Complexes, simplicial, singular and Cech Homology Theory. Homotopy groups and basic theorems of algebraic topology.

MATH 555-556 Introduction to Combinatorial Topology I-II. (3-3 Hours) Prerequisites: Mathematics 553 and approval of department. Properties of topological spaces; Jordan's theorem, surfaces, complexes, coverings, dimension; the Betti Groups,

homology theory, manifolds, the duality theorems, cohomology groups of compacta, introduction to theory of continuous mappings of polyhedra.

MATH 557-558 Introduction to Algebraic Geometry I-II. (3-3 Hours) Prerequisites: Mathematics 512, 521, or approval of the department. Algebraic preliminaries, local rings valuation theory, power series, rings, and geometry of algebraic varieties with emphasis on curves and surfaces.

MATH 559-560 Linear Programming I-II. (3-3 Hours) Basic Concepts, graph theory, theory of games, Markov Chains, Leontief Economic Models, Optimizing linear functions of variables subject to constraints, a geometric approach, simplex method, convex sets duality, applications.

MATH 561-562 Probability and Statistics I-II. (3-3 Hours) Prerequisite: Mathematics 532 or approval of department. Basic concepts of measure theory and integration axiomatic foundations of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, and decision functions.

MATH 563-573 Design I-II. (3-3 Hours) Prerequisite: Mathematics 272. Experimental Design: Completely randomize design; randomize block designs, factorial experiments split plot design, confounding.

MATH 564 Linear Models. (3 Hours) Prerequisite: Mathematics 562 or departmental approval. Linear statistical models, some noise-reducing experimental designs, an example-of a volume-increasing design, fitting the general linear model, inference making, multi parameter hypothesis: the analysis of variance, the effect of coding on the analysis, seeking a maximum or minimum response, fractional factorial experiments and incomplete block designs, an example of a completely random model, mixed models.

MATH 565 Multivariate Analysis. (3 Hours) Prerequisites: Mathematics 562 and approval of department. General linear hypothesis; least square estimation; confidence regions, multiple comparison; analysis of complete layouts; effects of departures from underlying assumptions. Analysis of covariance.

MATH 566-566W Operations Research. (3-3 Hours) Prerequisite: Math 232, 355. Linear programming, network analysis, PERT-CPM, dynamic programming, queuing theory and decision analysis.

MATH 567-568 Nonparametric Statistics I-II. (3-3 Hours) Prerequisites: Mathematics 562 and approval of department. Problems of estimating testing hypotheses when the functional form of the underlying distribution is unknown. Robust methods; sign test, rank test and confidence procedures based on these tests; tests based on permutations of observations. Non-parametric tolerance limits; large sample properties of the tests, multi sample problems; ranking methods in analysis of variance; Bivariate and multivariate procedures, efficiency comparisons.

MATH 569-570 Functions of Several Real Variables I-II. (3-3 Hours) Prerequisites: Mathematics 533 and approval of department. Euclidean spaces, Mapping and differentials, manifolds, differential forms, vector analysis.

MATH 571 Numerical Analysis I (3 Hours): This course is an introduction to parallel computer programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations.

MATH 572 Numerical Analysis II (3 hrs): This course is a continuation of MATH 625. Topics covered include, iterative solution of systems of nonlinear equations, evaluation of eigenvalues and eigenvectors of matrices, applications to simple partial differential equations and quantitative exploration of data.

MATH 573 Fractal Geometry. (3 Hours) Prerequisite: Math 511 or departmental approval. Metric spaces, equivalent spaces, classification of subsets, and the Space of Fractals. Transformations on metric spaces, contraction mappings, and the Construction of Fractals. Chaotic Dynamics of Fractals, Fractal Dimension. Fractal Interpolation. Julia Sets. Parameter Spaces and Mandelbrot Sets. Measures on Fractals.

MATH 574 Numerical Linear Algebra. (3 Hours) Prerequisite: Approval of department. Elementary numerical analysis; matrix algebra; elimination and compact elimination methods; orthogonalization methods; condition, accuracy, and precision; comparison of methods; iterative and gradient methods; iterative and transformation methods for latent roots and vectors; error analysis for latent roots and vectors.

MATH 575-576 Approximation and Interpolation I-II. (3-3 Hours) Prerequisite: Approval of department. Interpolation, remainder theory; convergence theorems; infinite interpolation; uniform approximation; best approximation; least squares approximation; Hilbert space; orthogonal polynomials; closure and completeness.

MATH 577-578 Ordinary Differential Equation I-II. (3-3 Hours) Ordinary differential equations: basic theorems of existence, uniqueness, and continuous dependence of the solutions; linear differential equations and systems; stability theory; topology of integral curves; differential equations in the complex domain, asymptotic integration; boundary value problems. Partial differential equations; equations of first order method of characteristics, Hamilton-Jacobi theory; equations of second order-classification according to type; elliptic equations-potential equation, maximum principle, characteristics, and other topics of interest.

MATH 579-580 Partial Differential Equations I-II. (3-3 Hours) Prerequisite: Mathematics 577 or departmental approval. Linear equations with constant coefficients in two independent variables, applications, eigenfunction expansions, homogeneous and nonhomogeneous equations. Fourier series, existence, solution uniqueness and representation, Initial boundary value problems, Laplace's equation, and special topics.

MATH 581-582 Number Theory I-II. (3-3 Hours) Prerequisites: Approval of department. Diophantine

analysis, primes, residue classes, theorems of Euler, Fermat, and Wilson, Continued Fractions, Chinese Remainder Theorem, quadratic reciprocity, valuations, extensions of valuations, local and global fields, discriminant.

MATH 583 Advanced Number Theory. (3 Hours) Prerequisite: Mathematics 581 or departmental approval. Quadratic and Cyclotomic extensions, elementary class field theory, and selected topics.

MATH 584 Independent Study. (3 Hours) Prerequisite: Departmental consent. Intensive study and research of a subject selected in accordance with student needs and arranged in consultation with the staff. Topics will vary. Student will make periodic reports on his/her reading and will-prepare a scholarly paper on a problem.

MATH 588-589 Sampling Methods I-II. (3-3 Hours) Prerequisite: Mathematics 272. Sampling methods: Simple random sampling, sampling for proportions and percentages, estimation of sample size, stratified random sampling ratio estimates.

MATH 590 Thesis. (3 Hours) The candidate for the Master of Science in Teaching degree must present a Thesis embodying the results of the research. The candidate chooses the problem, but approval by the adviser is required.

MATH 599 Thesis. (3 Hours) The candidate for the Master's degree must present a Thesis embodying the results of the research. The candidate chooses the problem, but approval by the adviser is required.

MATH 628 Advanced Partial Differential Equations I (3 Hours): The theory of initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations, with emphasis on nonlinear equations. Laplace's equation, heat equation, wave equation, nonlinear first-order equations, conservation laws, Hamilton-Jacobi equations, Fourier transform, Sobolef and other spaces, etc.

MATH 629 Advanced Partial Differential Equations II (3 Hours): The theory of boundary value and initial value problems for partial differential equations, with emphasis on nonlinear equations. Second-order elliptic equations, parabolic and hyperbolic equations, calculus of variations methods, additional topics selected by instructor.

MATH 670 Computational Methods in Mathematics I (3 Hours): This course is designed to give an overview of the design, analysis and implementation of the most fundamental numerical techniques in numerical linear algebra, the interpolation of functions, and the evaluation of integrals. This course in most part will depend on programming with MATLAB and/ or C++. While we present many MATLAB examples throughout the course, students are strongly advised to have some previous programming experience in any computer programming language.

MATH 671 Computational Methods in Mathematics II (3 Hours): This course is a continuation of MATH 770. Topics covered includes introduction to mathematical and computational problems arising in the context of molecular biology. Theory and applications of combinatorics, probability, statistics, geometry, and topology to problems ranging from sequence determination to structure analysis. The course depends on parallel and distributed programming.

MATH 673 Quantitative Exploration of Data (3 Hours): This course covers how to analyze and mine data with the Structured Query Language (SQL). Understand SQL fundamentals, and then advance into the uses of SQL data analysis and data mining with real applications. Learn to use Microsoft Excel to further analyze, manipulate and present your data exploration and data-mining findings in tabular and graphical formats. Students will be exposed to Extreme Science and Engineering Discovery Environment (XSEDE).

MATH 700 Mathematical and Statistical Applications (3 Hours): The course may be repeated for credit. It covers current trends and challenges of mathematical and statistical applications in CDS&E.

MATH 827 Numerical Solution of Differential Equations (3 Hours): Ordinary differential equations: Runge-Kutta and predictor-corrector methods; stability theory, Richardson extrapolation, stiff equations, boundary value problems. Partial differential equations: stability, accuracy and convergence, Von Neumann and CFL conditions, finite difference solutions of hyperbolic and parabolic equations. Finite differences and finite element solution of elliptic equations

STAT 661 Advanced Probability and Statistics (3 Hours): Prerequisite: Mathematics 532 or approval of department. Basic concepts of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, and decision functions.

STAT 672 Computational Statistics (3 Hours): Prerequisite: Departmental approval. This course covers R, SAS, SPSS, S-Plus, Mathematica, computational statistics packages and other big data statistical computational packages with emphasis on reading, manipulating , summarizing and modeling data and implementations of simulation through random number generating, Monte Carlo method and bootstrapping.

STAT 680 Computational Data Analysis and Visualization I (3 Hours): This course is about learning the fundamental computing skills necessary for effective data analysis.

STAT 681 Computational Data Analysis and Visualization II (3 Hours): This course covers exploratory and objective data analysis methods applied to the physical, engineering, and biological sciences.

STAT 800 Mathematical and Statistical Applications (3 Hours): Prerequisite: STAT 272 or approval of department. This course covers basic probability theory, common probability distributions, point and interval estimations, hypothesis testing, non-parametric tests, ANOVA as well as their applications.

Dissertation Course

CDSE 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Mathematics and Statistical Sciences. Prerequisite: permission of advisor.

GRADUATE ENGINEERING PROGRAM

The Graduate Engineering Program includes both M.S. and Ph.D. degrees in engineering. Enrolled students may specialize in one or more of the eight areas of emphasis including: Civil Engineering, Environmental Engineering, Geological Engineering, Coastal Engineering, Computer Engineering, Computational Engineering, Electrical Engineering, or Telecommunications Engineering.

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Master of Science in Engineering

Program Mission
Jackson State University offers course work leading to the Master of Science in Engineering through the Graduate Engineering Program in collaboration with the Department of Civil and Environmental Engineering and Industrial Systems and Technology, and the Department of Electrical & Computer Engineering and Computer Science. Engineering students may pursue a MS degree with emphasis in Civil Engineering, Environmental Engineering, Geological Engineering, Computer Engineering, Computational Engineering, Electrical Engineering, or Telecommunications Engineering. The Programs offers a non-degree admission for engineers in the Jackson area who are only interested in continuing engineering education or desire preparation for the Professional Engineering (PE) Exam.

One objective of the Graduate Engineering Program is to meet the post-graduate engineering educational needs of individuals in the greater Jackson metro area who are employed full time. The curriculum is designed not only to meet individual needs, but to provide courses that upgrade the technical skills of employees in private industry, and municipal, state and federal agencies. Classes are typically taught in the evenings to accommodate the working student. The Graduate Engineering Program provides an environment that accommodates full time graduate engineering students who plan to pursue careers in engineering practice, research or academia

Admission Requirements
Admission is open to applicants with an undergraduate degree in engineering. Applicants with an undergraduate degree in a closely related field may be considered. Engineering applicants may be admitted to the Graduate School as Regular Graduate Students, Qualifying Students, Conditional Students or Non-Degree Students. Admission requirements for each of these categories are outlined in the JSU Graduate Catalog. Applicants may have to satisfy undergraduate coursework prerequisites as determined by their Department Chairperson and/or Advisor.

Applicants must also submit three (3) letters of recommendations and must meet all other admission requirements outlined in the Jackson State University Graduate Catalog. In addition, international applicants must submit all documentation as outlined in the Graduate Catalog. All applicants must comply with the admission date deadlines of The Division of Graduate Studies.

Transfer of Graduate Credit
Engineering Graduate students may transfer up to 9 semester hours of graduate credit from another institution upon the recommendation of their advisor and approval by the Department Chairperson.

Time Limit
All course work applied toward a Master of Science Degree in Engineering must be completed within an 8-calendar year period from the date of first entering the graduate program.

Degree Requirements
Thirty(30), or thirty-six (36), semester hours are required for the Master of Science Degree in Engineering depending upon which of the following three options the student selects with approval of his or her department chairperson and/or advisor:

Option 1	Twenty four (24) semester hours of coursework plus a six-hour thesis
Option 2	Twenty seven (27) semester hours of coursework plus a three-hour project
Option 3	Thirty six (36) semester hours of coursework

Option 1	Requires a formal written thesis, formal presentation and oral exam.
Option 2	Requires a written project report, formal presentation and oral exam.
Option 3	Requires an oral exam.

To remain in "good standing", students must maintain a minimum cumulative grade point average (GPA) of 3.0 ("B" average).

Core Courses
Each emphasis area has either three or four core courses (9 to 12 semester hours). Electives are selected with approval of the student's graduate committee and/or graduate advisor.

Note: Please refer to the Department of Computer Science for admission and degree requirements, as well as emphasis areas, core courses and description of all courses for the Master of Science in Computer Science.

Civil Engineering Emphasis

Mission
To provide graduate learning opportunities in civil engineering for acquiring the knowledge, skills and attitudes necessary for practice and life-long professional development; to contribute to the expansion of knowledge of civil engineering through research programs; and to provide professional and community service to the state, the nation, and the world.

Program Objectives
1. Provide the depth and breathe in civil engineering topics necessary for civil engineering practice and development.
2. Provide graduate education in specialized civil engineering areas.
3. Contribute to the discovery of new knowledge and methods that enhance the theory and practice of civil engineering; and engage in meaningful service activities.
4. Provide an environment that promotes professional development, growth of the intellect, character, and spirit of students, faculty, and staff.

Program Requirements
The students are required to select three courses among the list of core courses. The three courses must be approved by the Department prior to selection. The remaining courses may be chosen from the list of electives or from the other core courses with the approval of the student's advisor.

Core Courses

Course	Title	Semester Hours
CIV 530	Advanced Pavement Analysis and Design	3
CIV 531	Traffic Engineering	3
CIV 532	Pavement Materials and Design	3
CIV 540	Advanced Structural Analysis	3
CIV 541	Structural Dynamics	3
CIV 542	Advanced Design of Concrete Structures	3
CIV 550	Engineering Hydrology	3
CIV 551	Advanced Fluid Mechanics	3
CIV 652	Hydraulic Engineering Design	3
CIV 672	Advanced Geomechanics	3
CIV 673	Advanced Foundation Engineering	3
CIV 674	Soil Dynamics	3

Elective Courses

CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 533	Evaluation, Maintenance, and Rehabilitation of Public Works Infrastructure	3
CIV 534	Urban Transportation Engineering System Design	3
CIV 535	Pavement Design	3
CIV 536	Highway Engineering	3
CIV 543	Advanced Mechanics of Materials	3
CIV 544	Advanced Design of Steel Structures	3
CIV 545	Advanced Design of Wood and Masonry Structures	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 553	Experimental Methods in Civil Engineering	3
CIV 554	Water Resources Engineering Planning and Management	3
CIV 556	Groundwater Engineering	3
CIV 557	Computational Fluid Dynamics	3
CIV 558	Sedimentation and River Engineering	3
CIV 559	Environmental Hydraulics	3
CIV 562	Hazardous Waste Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 571	Principles of Geo-environmental Engineering	3
CIV 572	Applied Geotechnical Engineering Design	3
CIV 578	Applied Geophysics	3
CIV 631	Linear Theory of Ocean Waves	3
CIVL 631	Linear Theory of Ocean Waves' Laboratory	1
CIV 632	Tides and Long Waves	3
CIV 633	Airport Planning and Design	3
CIV 640	Finite Element Method	3
CIV 642	Prestressed Concrete Design	3
CIV 645	Plates and Shells	3
CIV 650	Small Watershed Hydrology	3
CIV 653	Advanced Design of Hydraulic Structures	3
CIV 654	Water Resources Systems Engineering	3
CIV 655	Stochastic Hydrology	3
CIV 659	Advanced Topics in Water Resource Engineering	1-4
CIV 663	Design of Environmental Engineering Facilities	3
CIV 670	Rock Mechanics	3
CIV 675	Earth Dams and Slopes	3
CIV 676	Tunneling	3
CIV 677	Design and Construction with Geosynthetics	3
CIV 678	Soil Bioengineering	3
CIV 679	Advanced Topics in Geotechnical Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 681	Excavation Support Systems and Retaining Structures	3
CIV 682	Computational Geotechnics	3
CIV 683	Soil Structure Interactions	3
CIV 684	Advanced Site Characterization and Instrumentation 3and Instrumentation	3
CIV 695	Scientific Writing Seminar	1
CIV 696	Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4
CIV 699	Thesis Research	1-6

Environmental Engineering Emphasis

Mission

To provide engineers and scientists with advanced graduate education in the broad areas of environmental engineering

Program Objectives

1. Provide students an understanding of fundamental scientific and engineering principles necessary to manage and solve environmental challenges in natural and engineered systems
2. Provide advanced course work and research programs in environmental engineering
3. Enable students to develop increased professional competence in the broad areas of environmental engineering

Core Courses

Course	Title	Semester Hours
CIV 561	Chemistry for Environmental Engineering	3
CIV 562	Hazardous Waste Engineering	3

CIV 660	Physicochemical Processes in Water and Wastewater	3
CIV 661	Biological Processes in Wastewater Engineering	3

Elective Courses

CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 550	Engineering Hydrology	3
CIV 551	Advanced Fluid Mechanics	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 560	Environmental Engineering II	3
CIV 563	Microbiology for Environmental Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 566	Air Pollution and Control	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 569	Environmental Systems Modeling	3
CIV 571	Principles of Geo-environmental Engineering	3
CIV 573	Environmental Geology for Engineers	3
CIV 574	Engineering Hydrogeology	3
CIV 575	Applied Geological Engineering	3
CIV 631	Linear Theory of Ocean Waves	3
CIVL 631	Linear Theory of Ocean Waves' Laboratory	1
CIV 632	Tides and Long Waves	3
CIV 650	Small Watershed Hydrology	3
CIV 652	Hydraulic Engineering Design	3
CIV 653	Advanced Design of Hydraulic Structures	3
CIV 663	Design of Environmental Engineering Facilities	3
CIV 664	Limnology for Environmental Engineering	3
CIV 665	Environmental Law	3
CIV 666	Advanced Waste Treatment Processes in Environmental Engineering	3
CIV 667	Biological Process Engineering	3
CIV 668	Bioenvironmental Engineering	3
CIV 669	Advanced Topics in Environmental Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 681	Excavation Support Systems and And Retaining Structures	3
CIV 682	Computational Geotechnics	3
CIV 683	Soil Structure Interactions	3
CIV 684	Advanced Site Characterization And Instrumentation	3
CIV 695	Scientific Writing Seminar	1
CIV 696	Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4
CIV 699	Thesis Research	1-6

Coastal Engineering Emphasis

Mission

To provide engineers with graduate education in the specialized field of coastal engineering, including knowledge, skills and abilities to address coastal engineering challenges arising from coastal natural disasters.

Program Objectives

1. Provide students an understanding of the fundamental coastal engineering knowledge and principles necessary to address engineering challenges in a coastal environment, especially those arising from coastal natural disasters.
2. Provide graduate course work and research programs in coastal engineering.
3. Enable students to achieve enhanced professional development and to appreciate the technical and societal challenges existing in the practice of coastal engineering.

Program Requirements

The students are required to select four courses among the list of seven core courses and one of the four must be CIV 520. The other three core courses must be approved by the Department prior to selection. The remaining courses may be chosen from the list of electives or from the other core courses with approval of the student's advisor.

Core Courses

Course	Title	Semester Hours
CIV 520	Advanced Engineering Analysis I	3
CIV 538	Coastal Structures	3
CIV 539	Advanced Coastal Engineering Design	3
CIV 558	Sedimentation and River Engineering	3
CIV 631	Linear Theory of Ocean Waves Theory	3
CIV 636	Spectral Wave Analysis	3
CIV 637	Advanced Design for Breakwater Rehabilitation	3

Elective Courses

Course	Title	Semester Hours
CIV 521	Advanced Engineering Analysis II	3
CIV 530	Advanced Pavement Analysis and Design	3
CIV 531	Traffic Engineering	3
CIV 532	Pavement Materials and Design	3
CIV 533	Evaluation, Maintenance, & Rehabilitation of Public Works Infrastructure	3
CIV 534	Urban Transportation Engineering System Design	3
CIV 540	Advanced Structural Analysis	3

CIV 541	Structural Dynamics	3
CIV 542	Advanced Design of Concrete Structures	3
CIV 550	Engineering Hydrology	3
CIV 551	Advance Fluid Mechanics	3
CIV 552	GIS Applications	3
CIV 553	Environmental. Methods in Civil Engineering	3
CIV 554	Water Resources Engineering Planning and Management	3
CIV 556	Groundwater Engineering	3
CIV 557	Computational Fluid Dynamics	3
CIV 558	Sedimentation and River Engineering	3
CIV 559	Environmental Hydraulics	3
CIV 562	Hazardous Waste Engineering	3
CIV 564	Surface Water	3
CIV 632	Tides and Long Waves	3
CIV 633	Airport Planning and Design	3
CIV 640	Finite Element Method	3
CIV 650	Small Watershed Hydrology	3
CIV 652	Hydraulic Engineering Design	3
CIV 659	Advanced Topics in Water Resources Engineering	1-4
CIV 670	Rock Mechanics	3
CIV 680	Unsaturated Soil Mechanics	3
CIV 681	Excavation Support Systems and Retaining Structures	3
CIV 682	Computational Geotechnics	3
CIV 683	Soil Structure Interactions	3
CIV 684	Advanced Site Characterization and Instrumentation	3
CIV 695	Scientific Writing Seminar	3
CIV 696	Seminar	3
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4
CIV 699	Thesis Research	1-6

Geological Engineering Emphasis

Mission

To provide a high quality graduate education in the traditional and emerging areas of geological engineering which is locally responsive; to contribute to the expansion of knowledge of geological engineering through programs of basic and applied research; and to provide professional and community service to the state, the nation, and the world.

Program Objectives

1. Provide a graduate education in the broad area of geological engineering fundamentals.
2. Provide academic education and real world design experiences to prepare students for practice in the geological engineering profession.
3. Make contributions to the advancement of knowledge in geological engineering; and engage in meaningful service activities.
4. Create and maintain an environment that promotes professional development, growth of the intellect, character, and spirit of students, faculty and staff.

Core Courses

Course	Title	Semester Hours
CIV 570	Regional Geological Engineering	3
CIV 571	Principles of Geo-environmental Engineering	3
CIV 575	Applied Geological Engineering	3
CIV 673	Advanced Foundation Engineering	3

Elective Courses

CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 572	Applied Geotechnical Engineering Design	3
CIV 573	Environmental Geology for Engineers	3
CIV 574	Engineering Hydrogeology	3
CIV 578	Applied Geophysics	3
CIV 579	Engineering Seismology	3
CIV 670	Rock Mechanics	3
CIV 671	Advanced Topics in Geological Engineering	1-4
CIV 672	Advanced Geo-mechanics	
CIV 674	Soil Dynamics	3
CIV 675	Earth Dams and Slopes	3
CIV 676	Tunneling	3
CIV 677	Design and Construction with Geosynthetics	3
CIV 678	Soil Bioengineering	3
CIV 679	Advanced Topics in Geotechnical Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 681	Excavation Support Systems and Retaining Structures	3
CIV 682	Computational Geotechnical	3
CIV 683	Soil Structure Interactions	3
CIV 684	Advanced Site Characterization and Instrumentation	3
CIV 695	Scientific Writing Seminar	1
CIV 696	Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4
CIV 699	Thesis Research	1-6

#Note: At least two courses must be selected among CIV 573, CIV 574, CIV 576, CIV 577, CIV 579 and

CIV 671. In addition, at least one course must be selected among CIV 578, CIV 670, CIV 672, CIV 674, CIV 675, CIV 677 and CIV 679.

Electrical Engineering Emphasis

Mission

Provide students with a solid foundation in electrical engineering, knowledge of technical specialty areas, and an appreciation for collaborative problem solving in order to make significant contributions to the profession.

Program Objectives

1. Provide students with a solid foundation in electrical engineering (EE), EE practices;

   and major design skills
2. to maintain high employability, adaptability to changing technologies, and an ability to conceive new technologies and innovative solutions to EE challenges
3. Provide graduates with effective communication skills required for career advancement;
4. Endow students with a sense of professionalism, professional ethics and active participation in the affairs of the profession;
5. Enable students to work effectively in a team environment.

Core Courses

Course	Title	Semester Hours
CPE 551	Digital Signal Processing	3
CPE 555	Control Systems	3
CPE 560	Embedded Design With Microprocessors	3
CPE 635	Advanced Circuit Theory	3

Elective Courses

CPE 503	Computational Methods	3
CPE 515	Advanced Logic Design	3
CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 530	VLSI Design	3
CPE 531	VLSI Testing and Design for Testability	3
CPE 532	Digital Integrated Circuit Design	3
CPE 536	Solid State Electronics	3
CPE 539	Lasers	3
CPE 544	Electromagnetic Field Analysis	3
CPE 556	Systems Theory	3
CPE 557	Robotics	3
CPE 571	Engineering Foundations of Biomedical Engineering	3
CPE 573	Biomedical Instrumentation	3
CPE 575	Biomaterials	3
CPE 655	Advanced Control Systems	3
CPE 693	Advanced Topics in Engineering	1-4
CPE 695	Scientific Writing Seminar	1
CPE 696	Seminar	1
CPE 697	Internship	1-3
CPE 698	Independent Study	1-4
CPE 699	Thesis Research	1-6

Computer Engineering Emphasis

Mission

Provide a solid foundation in the design and implementation of computer systems emphasizing the development of both software and hardware. Provide an outstanding educational program that enables graduates to have a solid background in both theoretical and practical aspects of Computer Engineering in order to prepare them to make meaningful contributions to their profession. Provide an outstanding educational program that enables our graduates to become leaders in their profession by imparting fundamental principles, skills, and tools necessary to innovate and excel in engineering practice, research or academia.

Program Objectives

1. Afford students the opportunity for in-depth study of Computer Engineering concepts and theories
2. Provide state-of-the-art applications and implementations in the design of computer-based systems
3. Provide graduates with effective communications skills required for career advancement
4. Endow students with a sense of professionalism, professional ethics and active participation in the affairs of the profession
5. Engage faculty and graduate students in meaningful Computer Engineering research
6. Promote professional development and growth of students and faculty

Core Courses

Course	Title	Semester Hours
CPE 508	Operating Systems	3
CPE 512	Computer Architecture	3
CPE 515	Advanced Logic Design	3
CPE 541	Computer Networks	3

Elective Courses

CPE 500	Software Engineering	3
CPE 505	Analysis of Algorithms	3
CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 530	VLSI Design	3
CPE 531	VLSI Testing and Design for Testability	3
CPE 532	Digital Integrated Circuit Design	3
CPE 533	Fault-Tolerant Computing Systems	3
CPE 547	Modeling and Analysis of	3

	Computer and Communication Systems	
CPE 552	Computer Vision	3
CPE 555	Control Systems	3
CPE 557	Robotics	3
CPE 560	Embedded Design with Microprocessors	3
CPE 601	Code Optimizations	3
CPE 610	Parallel Computing and Programming	3
CPE 611	Computer Arithmetic	3
CPE 630	Design Automation of VLSI Systems	3
CPE 640	Computer Security	3
CPE 641	Advanced Computer Networks	3
CPE 642	Computer Network Security	3
CPE 655	Advanced Control Systems	3
CPE 693	Advanced Topics in Engineering	1-4
CPE 695	Scientific Writing Seminar	1
CPE 696	Seminar	1
CPE 697	Internship	3
CPE 698	Independent Study	1-4
CPE 699	Thesis Research	1-6

Telecommunications Engineering Emphasis

Mission

To provide quality education to prepare students to play a significant role in shaping the future telecommunication's environment, and to provide knowledge and skills necessary to foster life-long learning.

Program Objectives

1. Provide students with both theoretical and practical foundations of telecommunications engineering
2. Engage faculty and students in research endeavors in telecommunications hardware, software, and systems
3. Promote professional development and growth of students and faculty
4. Produce graduates with effective communications skills required for career advancement
5. Endow students with a sense of professionalism, professional ethics and active participation in the affairs of the profession

Core Courses

Course	Title	Semester Hours
CPE 540	Telecommunication Systems	3
CPE 541	Computer Networks	3
CPE 543	Wireless Communication Systems	3
CPE 551	Digital Signal Processing	3

Elective Courses

CPE 500	Software Engineering	3
CPE 502	Telecommunication Software Design	3
CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 534	Coding Theory	3
CPE 542	Computer and Network Security	3
CPE 545	Antennas	3
CPE 546	Digital Communication Systems	3
CPE 643	Wireless Networks	3
CPE 644	Optical Communication Systems	3
CPE 645	Microwave Circuits and Systems	3
CPE 646	Global Positioning Systems and Location Services	3
CPE 647	Mobile Computing Systems	3
CPE 648	Wireless Sensor Networks	3
CPE 649	Telecommunications Network Management	3
CPE 670	Wireless Design Laboratory	3
CPE 671	3G and 4G Wireless Networks	3
CPE 672	Network Quality Assurance and Simulation	3
CPE 673	Wireless Internet Application Development	3
CPE 693	Advanced Topics in Engineering	1-4
CPE 695	Scientific Writing Seminar	1
CPE 696	Seminar	1
CPE 697	Internship	1-3
CPE 698	Independent Study	1-4
CPE 699	Thesis Research	1-6

Computational Engineering Emphasis

It is essential for engineers to be skillful in computational technologies. Emergence of high-performance computing has created a third mode of scientific investigation. Computational simulation now joins theoretical analysis and physical experimentation as tools for discovering new knowledge.

Program Objectives

1. Develop computational systems for the solution of physical problems in engineering and science.
2. Develop algorithms and software required for the mathematical models of physical processes.
3. Visualize, analyze, and interpret computed results and other physical data.

Core Courses

Course	Title	Semester Hours
CPE 503	Computational Methods	3
CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 618	High Performance Computing	3

Elective Courses

CPE 500	Software Engineering	3
CPE 505	Analysis of Algorithms	3
CPE 508	Operating Systems	3
CPE 512	Computer Architecture	3
CPE 515	Advanced Logic Design	3
CPE 530	VLSI Design	3
CPE 531	VLSI Testing and Design for Testability	3
CPE 532	Digital Integrated Circuit Design	3
CPE 533	Fault-Tolerant Computing Systems	3
CPE 541	Computer Networks	3
CPE 547	Modeling and Analysis of Computer and Communication Systems	3
CPE 552	Computer Vision	3
CPE 555	Control Systems	3
CPE 557	Robotics	3
CPE 560	Embedded Design with Microprocessors	3
CPE 601	Code Optimizations	3
CPE 610	Parallel Computing and Programming	3
CPE 611	Computer Arithmetic	3
CPE 630	Design Automation of VLSI Systems	3
CPE 640	Computer Security	3
CPE 641	Advanced Computer Networks	3
CPE 642	Computer Network Security	3
CPE 655	Advanced Control Systems	3
CPE 693	Advanced Topics in Engineering	1-4
CPE 695	Scientific Writing Seminar	1
CPE 696	Seminar	1
CPE 697	Internship	1-3
CPE 698	Independent Study	1-4
CPE 699	Thesis Research	1-6

Doctor of Philosophy (Ph.D.) in Engineering

Program Description

The Ph.D. in Engineering Program consists of 7 emphasis areas including Computer Engineering, Telecommunications Engineering, Electrical Engineering, Computational Engineering, Civil Engineering, Environmental Engineering, and Geological Engineering.

Mission

To provide students with the necessary advanced knowledge, research skills, creativity, ethics, critical thinking, and problem solving to be able respond to engineering challenges and needs of our ever-changing world for professional competence and life-long and inquiry-based learning.

Objectives

The primary educational objective of the Ph.D. in Engineering Program is to produce engineers with terminal degrees to meet the needs for highly educated engineers with advanced technical and research skills in the workforces. The specific objectives of the seven emphasis areas are as following:

Civil Engineering: to prepare students for continued professional and scholarly development consistent with their technical interests in civil engineering by conducting a major independent and original research study with critical thinking.

Environmental Engineering: to equip students with advanced knowledge and skills in the environmental engineering field and produce graduates with competencies in advanced original research, education, and professional practice in the area of environmental engineering.

Geological Engineering: to train students with advanced knowledge and scholarly development in geological engineering and produce graduates with competency in advanced original research in the area of geological engineering.

Computer Engineering: to equip students with advanced knowledge in computer engineering and produce graduates with competencies in advanced original research, education, and professional practice in computer engineering.

Telecommunications Engineering: to equip students with advanced knowledge in telecommunications engineering and produce graduates with competencies in advanced original research, education, and professional practice in telecommunications engineering.

Electrical Engineering: to equip students with advanced knowledge in electrical engineering and produce graduates with competencies in advanced original research, education, and professional practice in electrical engineering.

Computational Engineering: to equip students with advanced knowledge in computational engineering and produce graduates with competencies in advanced original research, education, and professional practice in computational engineering.

Admission Requirements

The applicants must meet all admission requirements set by the Division of Graduate Studies. In addition,

the applicants must meet the following admission requirements.

1. A Bachelor of Science (B.S.) degree in civil engineering, environmental engineering, computer engineering, or electrical engineering or closely related engineering disciplines from accredited colleges and universities, or a Master of Science (M.S.) in related engineering field.
2. Applicants who do not have a B.S. or M.S. in an engineering field will be required to satisfy the articulation courses.
3. Minimum undergraduate grade point average (GPA) of 3.0 on a 4.0 scale and minimum graduate GPA of 3.50 on a 4.0 scale are required. In special cases, exceptional applicants with B.S. degrees in engineering will be considered. These applicants must have a minimum GPA of 3.5
4. Applicants with Minimum undergraduate grade point average (GPA) of 2.90 on a 4.0 scale and minimum graduate GPA of 3.250 on a 4.0 scale may be considered for conditional admission. These applicants must achieve a minimum graduate GPA of 3.50 during the first year of the Ph.D. Program to be eligible for consideration for regular admission.
5. International students must meet the English requirements as outlined by the Division of Graduate Studies.
6. Applicant must submit three letters of recommendation from professionals who are knowledgeable with applicant's credentials.
7. Applicant must submit a one-page statement on career goals and objectives, as well as research experience and interests.

Degree Requirements

The applicants must meet all degree requirements set by the Division of Graduate Studies. In addition, the applicants must meet the following degree requirements.

To obtain the Ph.D. in Engineering Degree, the students are required to complete a minimum of 72 credit hours beyond B.S. or 36 credit hours beyond M.S. degree. The program includes core courses, elective courses, and 24 hours of dissertation research. The adviser or the advising committee may recommend additional courses based on the students background and proposed research plan. Students have to maintain a graduate GPA of 3.0 or above to avoid academic probation.

A comprehensive qualifying exam is given to the student after six months of the study beyond the M.S. degree, but no later than after 2 years of study. Academic advisor and engineering faculty in a student's area of research determine the coursework needed for a student to prepare for the comprehensive qualifying examination. The comprehensive qualifying examination includes a written part and oral exam. During the comprehensive qualifying examination, students must demonstrate a sufficient depth and breadth of knowledge in their major to pursue independent and original research. However, the student must consult with their advisor and/or the exam coordinator in the major area of study for the schedule and specific procedures. A signature form, verifying that a student has passed the comprehensive qualifying exam, must be signed by the student's advisor and returned to the departmental office. After passing the comprehensive qualifying exam, the students will be admitted to Ph.D. Candidacy. If a student fails to pass the comprehensive qualifying exam, he/she will be allowed to take it again between one and six months after the first attempt. If the student fails twice on this exam, he/she will be dropped from the PhD program.

When at least 80% of coursework is completed and the comprehensive qualifying exam is successfully passed, the students are able to take a preliminary exam administered by the advising committee and academic advisor. Students should take the preliminary exam within 3 years of residence beyond the MS degree and at least two semesters before their final dissertation defense. This exam is based upon an oral exam and a written proposal and a detailed plan to carry out the Ph.D. dissertation. Students must consult with their advisors for specific details of the requirements for the preliminary exam.

The defense of dissertation is the final exam of the Ph.D. program. An oral defense and a written Ph.D. dissertation demonstrating original and independent research and major contributions to an engineering field have to be approved by the advising committee before graduation. Recognizing the importance of high quality graduates, each graduate is expected to publish at least 2 papers based on the results of his/her research in high quality refereed engineering journals. A summary of minimum degree requirements is shown below.

Summary of Minimum Degree Requirements for Ph.D. in Engineering

Credit Hours
A minimum of 72 credit hours beyond B.S. or 36 credit hours beyond M.S. degree. Must complete 24 hours of dissertation research, the required core courses, and elective courses. The adviser or the advising committee may recommend additional courses based on the students background and the proposed research area.

Comprehensive Qualifying Exam
Successful completion of written and oral Comprehensive Qualifying Exam, given after six months of the study beyond the M.S. degree, but no later than after 2 years of study.

Preliminary Exam
Successful completion of the preliminary exam within 3 years of residence beyond the MS degree and at least two semesters before their final dissertation defense.

Final Dissertation and Defense

An oral defense and a written Ph.D. dissertation demonstrating original independent research and major contributions. Each graduate is expected to publish at least 2 papers based on the results of his/her research in high quality refereed engineering journals.

Program: Ph.D. in Engineering
Emphasis area: Civil Engineering
Department: Civil and Environmental Engineering

Core Courses

1. Choose three from the following list after consultation and approval of the student's adviser.

Course	Title	Semester Hours
CIV 530	Advanced Pavement Analysis and Design	3
CIV 531	Traffic Engineering	3
CIV 532	Pavement Materials and Design	3
CIV 540	Advanced Structural Analysis	3
CIV 541	Structural Dynamics	3
CIV 542	Advanced Design of Concrete Structures	3
CIV 550	Engineering Hydrology	3
CIV 551	Advanced Fluid Mechanics	3
CIV 652	Hydraulic Engineering Design	3
CIV 672	Advanced Geomechanics	3
CIV 673	Advanced Foundation Engineering	3
CIV 674	Soil Dynamics	3

2. In addition, each student is required to take one graduate level advanced mathematics course after consultation and approval of the student's adviser.

Elective Courses

CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 533	Evaluation, Maintenance, & Rehabilitation of Public Works Infrastructure	3
CIV 534	Urban Transportation Engineering System Design	3
CIV 535	Pavement Design	3
CIV 536	Highway Engineering	3
CIV 543	Advanced Mechanics of Materials	3
CIV 544	Advanced Design of Steel Structures	3
CIV 545	Design of Wood and Masonry Structures	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 553	Experimental Methods in Civil Engineering	3
CIV 554	Water Resources Engineering Planning and Management	3
CIV 556	Groundwater Engineering	3
CIV 557	Computational Fluid Dynamics	3
CIV 558	Sedimentation and River Engineering	3
CIV 559	Environmental Hydraulics	3
CIV 562	Hazardous Waste Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 571	Principles of Geoenvironmental Engineering	3
CIV 572	Applied Geotechnical Engineering Design	3
CIV 578	Applied Geophysics	3
CIV 631	Linear Theory of Ocean Waves	3
CIVL 631	Linear Theory of Ocean Waves' Laboratory	1
CIV 632	Tides and Long Waves	3
CIV 633	Airport Planning and Design	3
CIV 640	Finite Element Method	3
CIV 642	Prestressed Concrete Design	3
CIV 645	Plates and Shells	3
CIV 650	Small Watershed Hydrology	3
CIV 653	Advanced Design of Hydraulic Structures	3
CIV 654	Water Resources Systems Engineering	3
CIV 655	Stochastic Hydrology	3
CIV 659	Advanced Topics in Water Resources Engineering	1-4
CIV 663	Design of Environmental Engineering Facilities	3
CIV 670	Rock Mechanics	3
CIV 675	Earth Dams and Slopes	3

CIV 676	Tunneling	3
CIV 677	Design and Construction with Geosynthetics	3
CIV 678	Soil Bioengineering	3
CIV 679	Advanced Topics in Geotechnical Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 695	Scientific Writing Seminar	1
CIV 696	Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4

Program: Ph.D. in Engineering
Emphasis Area: Environmental Engineering
Department: Civil and Environmental Engineering

Core Courses

1. Choose three from the following list after consultation and approval of the student's adviser.

Course	Title	Semester Hours
CIV 561	Chemistry for Environmental Engineering	3
CIV 562	Hazardous Waste Engineering	3
CIV 660	Physiochemical Processes in Water and Wastewater	3
CIV 661	Biological Processes in Wastewater Engineering	3

2. In addition, each student is required to take one graduate level advanced mathematics course after consultation and approval of the student's adviser.

Elective Courses

Course	Title	Semester Hours
CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 550	Engineering Hydrology	3
CIV 551	Advanced Fluid Mechanics	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 558	Sedimentation and River Engineering	3
CIV 560	Environmental Engineering II	3
CIV 563	Microbiology for Environmental Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 566	Air Pollution and Control	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 569	Environmental Systems Modeling	3
CIV 571	Principles of Geoenvironmental Engineering	3
CIV 573	Environmental Geology for Engineers	3
CIV 574	Engineering Hydrogeology	3
CIV 575	Applied Geological Engineering	3
CIV 631	Linear Theory of Ocean Waves	3
CIV 631L	Linear Theory of Ocean Waves' Laboratory	1
CIV 632	Tides and Long Waves	3
CIV 650	Small Watershed Hydrology	3
CIV 652	Hydraulic Engineering Design	3
CIV 653	Advanced Design of Hydraulic Structures	3
CIV 663	Design of Environmental Engineering Facilities	3
CIV 664	Limnology for Environmental Engineering	3
CIV 665	Environmental Law	3
CIV 666	Advanced Waste Treatment Processes in Environmental Engineering	3
CIV 667	Biological Process Engineering	3
CIV 668	Bioenvironmental Engineering	3
CIV 669	Advanced Topics in Environmental Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 695	Scientific Writing Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4

Program: Ph.D. in Engineering
Emphasis Area: Geological Engineering
Department: Civil and Environmental Engineering

Core Courses

1. Choose three from the following list after consultation and approval of the student's adviser.

Course	Title	Semester Hours
CIV 570	Regional Geological Engineering	3
CIV 571	Principles of Geoenvironmental Engineering	3
CIV 575	Applied Geological Engineering	3
CIV 673	Advanced Foundation Engineering	3

2. In addition, each student is required to take one graduate level advanced mathematics course after consultation and approval of the student's adviser.

Elective Courses*

Course	Title	Semester Hours
CIV 520	Advanced Engineering Analysis I	3
CIV 521	Advanced Engineering Analysis II	3
CIV 552	GIS Applications in Civil and Environmental Engineering	3
CIV 564	Surface Water	3
CIV 565	Wetland Management for Environmental Engineering	3
CIV 567	Environmental Remediation	3
CIV 568	Land Disposal of Waste	3
CIV 572	Applied Geotechnical Engineering Design	3
CIV 573	Environmental Geology for Engineers	3
CIV 574	Engineering Hydrogeology	3
CIV 576	Geological Engineering Analysis	3
CIV 577	Airphoto Interpretation for Terrain Evaluation	3
CIV 578	Applied Geophysics	3
CIV 579	Engineering Seismology	3
CIV 670	Rock Mechanics	3
CIV 671	Advanced Topics in Geological Engineering	1-4
CIV 672	Advanced Geomechanics	3
CIV 674	Soil Dynamics	3
CIV 675	Earth Dams and Slopes	3
CIV 676	Tunneling	3
CIV 677	Design and Construction with Geosynthetics	3
CIV 678	Soil Bioengineering	3
CIV 679	Advanced Topics in Geotechnical Engineering	1-4
CIV 680	Unsaturated Soil Mechanics	3
CIV 695	Scientific Writing Seminar	1
CIV 696	Seminar	1
CIV 697	Internship	1-3
CIV 698	Independent Study	1-4

[a]Note: At least two courses must be selected among CIV 573, CIV 574, CIV 576, CIV 577, CIV 579, or CIV 671. In addition, at least one course must be selected among CIV 578, CIV 670, CIV 672, CIV 674, CIV 675, CIV 676, CIV 677, or CIV 679.

Program: Ph.D. in Engineering
Emphasis Areas:
(1) Computer Engineering
(2) Telecommunications Engineering
(3) Electrical Engineering
(4) Computational Engineering
Department: Electrical & Computer Engineering

Core Courses

The required four core courses are:

Core Courses

Course	Title	Semester Hours
CPE 503	Computational Methods	3
CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 635	Advanced Circuit Theory	3

Elective Courses

Course	Title	Semester Hours
CPE 500	Software Engineering	3
CPE 502	Telecommunication Software Design	3
CPE 503	Computational Methods	3
CPE 505	Analysis of Algorithms	3
CPE 508	Operating Systems	3
CPE 512	Computer Architecture	3
CPE 515	Advanced Logic Design	3

CPE 520	Advanced Engineering Analysis I	3
CPE 521	Advanced Engineering Analysis II	3
CPE 530	VLSI Design	3
CPE 531	VLSI Testing and Design for Testability	3
CPE 532	Digital Integrated Circuit Design	3
CPE 533	Fault-Tolerant Computing Systems	3
CPE 534	Coding Theory	3
CPE 536	Solid State Electronics	3
CPE 539	Lasers	3
CPE 540	Telecommunication Systems	3
CPE 541	Computer Networks	3
CPE 542	Computer and Network Security	3
CPE 543	Wireless Communication Systems	3
CPE 544	Electromagnetic Field Analysis	3
CPE 545	Antennas	3
CPE 546	Digital Communication Systems	3
CPE 547	Modeling and Analysis of Computer and Communication Systems	3
CPE 551	Digital Signal Processing	3
CPE 552	Computer Vision	3
CPE 555	Control Systems	3
CPE 556	Systems Theory	3
CPE 557	Robotics	3
CPE 560	Embedded Design with Microprocessors	3
CPE 571	Engineering Foundations of Biomedical Engineering	3
CPE 573	Biomedical Instrumentation	3
CPE 575	Biomaterials	3
CPE 601	Code Optimizations	3
CPE 610	Parallel Computing and Programming	3
CPE 611	Computer Arithmetic	3
CPE 618	High Performance Computing	3
CPE 630	Design Automation of VLSI Systems	3
CPE 635	Advanced Circuit Theory	3
CPE 640	Computer Security	3
CPE 641	Advanced Computer Networks	3
CPE 642	Computer Network Security	3
CPE 643	Wireless Networks	3
CPE 644	Optical Communication Systems	3
CPE 645	Microwave Circuits and Systems	3
CPE 646	Global Positioning Systems and Location Services	3
CPE 647	Mobile Computing Systems	3
CPE 648	Wireless Sensor Networks	3
CPE 649	Telecommunications Network Management	3
CPE 655	Advanced Control Systems	3
CPE 670	Wireless Design Laboratory	3
CPE 671	3G and 4G Wireless Networks	3
CPE 672	Network Quality Assurance and Simulation	3
CPE 673	Wireless Internet Applications Development	3
CPE 693	Advanced Topics in Engineering	1-4
CPE 695	Scientific Writing Seminar	1
CPE 696	Seminar	1
CPE 697	Internship	1-3
CPE 698	Independent Study	1-4

DESCRIPTION OF COURSES

CIV Courses

CIV 520 Advanced Engineering Analysis I. (3 Hours) A comprehensive course to familiarize engineering professionals with advanced applied mathematics as it relates to solving practical engineering problems. The course of intensive study blends the theoretical underpinnings of advanced applied mathematics with an understanding of how these powerful tools can be used to solve practical engineering problems. The material covered includes Ordinary Differential Equations; Linear Algebra, Vector Calculus; Fourier Analysis and Partial Differential Equations.

CIV 521 Advanced Engineering Analysis II. (3 Hours) A comprehensive course to familiarize engineering professions with advanced applied mathematics as it relates to solving practical engineering problems. The course of intensive study blends the theoretical use of advanced applied mathematics with an understanding of how these powerful tools can be used to solve practical engineering problems. The material covered includes Complex Analysis; Numerical Methods; Optimization; Graphs; and Probability and Statistics.

CIV 530 Advanced Pavement Analysis and Design. (3 Hours) Development of models for and analysis of pavement systems; use of transfer functions relating pavement response to pavement performance; evaluation and application of current pavement design practices and procedures; analysis of the effects of maintenance activities on pavement performance; and economic evaluation of highway and airport pavements. Prerequisite: CIV 475 or permission of Department.

CIV 531 Traffic Engineering. (3 Hours) Study of fundamentals of traffic engineering; analysis of traffic stream characteristics; capacity of urban and rural highways; design and analysis of traffic signals and intersection; traffic control; traffic impact studies; and traffic accidents. Prerequisite: CIV 390 or permission of Department.

CIV 532 Pavement Materials and Design. (3 Hours) Properties and control testing of bituminous materials, aggregates for bituminous mixtures, and analysis and design of asphalt, concrete and liquid asphalt cold mixtures; structural properties of bituminous mixes; surface treatment design; and recycling of mixtures. Introduction to Superpave mix design and applications. Prerequisite: CIV 390 or permission of Department.

CIV 533 Evaluation, Maintenance, and Rehabilitation of Public Works Infrastructure. (3 Hours) Evaluation, maintenance, and rehabilitation of deteriorated infrastructure systems by considering live cycle costs and long-term performance. Understanding rehabilitation alternatives used in the practical field and designing rehabilitation based on the nondestructive testing methods and economical considerations. Prerequisite: CIV 390 and CIV 475. (Cross Reference: CIV 479)

CIV 534 Urban Transportation Engineering System Design (3 Hours) Advanced design of highway systems, vehicle and driver characteristics, highway capacity, design of urban streets and expressways. Design constraints. Individual and team design projects oriented toward the solution of local urban transportation problems, societal and economical considerations. Prerequisite: CIV 390, CIV 310 and CIVL 310 or permission of Department. (Cross reference: CIV 470)

CIV 535 Pavement Design. (3 Hours) Aggregate, binder systems. Theory and design of pavement structures, rigid and flexible pavement designs, subgrade materials, pavement management, nondestructive testing, pavement maintenance, design constraints, infrastructure maintenance, major design project. Prerequisite: CIV 380 and CIV 390. (Cross reference: CIV 475)

CIV 536 Highway Engineering. (3 Hours) Analysis of factors in developing highway transportation facilities; traffic estimates and assignment; problems of highway geometrics and design standards; planning and location principles; intersection design factors; street systems and terminal facilities; programming improvements; drainage design; structural design of surface; concepts of highway management and finance; and highway maintenance planning. Prerequisite: CIV 390 or permission of Department.

CIV 538 Coastal Structures (3 Hours) The types and functions of coastal structures will be studied including, seawalls, groins, revetments, bulkheads, dikes, detached breakwaters, reef breakwaters, storm surge barriers and others. A coastal structure will be assigned to each student to provide the class a lecture to and prepare a term paper on the coastal structure assigned. Determination of the design wave climate for coastal structures is investigated as it pertains to the functional types of coastal structures. Invited guest lecturers will appear as available.

CIV 539 Advanced Coastal Engineering Design (3 Hours)

This course provides a comprehensive advanced investigation of the coastal engineering design process. It includes the Planning and Design Process, Site Characterization, Shore Protection Projects, Beach Fill Design, Navigation Projects, Sediment Management at Inlets and Environmental Enhancement. A design project will be assigned to each student to provide the class a power point presentation and to prepare a term paper on the design project assigned. Invited guest design professionals will appear and present lectures as available.

CIV 540 Advanced Structural Analysis. (3 Hours) A unified formulation of displacement and force methods of analysis including the topological view of the structure as an assemblage of members; matrix techniques of formulation; considerations for automatic computations; and evaluation of truss, grid, and frame models for the response of real structures. Prerequisite: CIV 320 or permission of Department.

CIV 541 Structural Dynamics. (3 Hours) Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; and introduction to systems with distributed mass and flexibility. Prerequisite: CIV 320 or permission of Department.

CIV 542 Advanced Design of Concrete Structures. (3 Hours) Theory and design of reinforced concrete continuous beams, slender columns, two-way-slabs, footings, retaining walls, shear walls and multistory buildings. Design for torsion and design constraints. Framing systems and loads for buildings and bridges, design constraints and a major design project. Prerequisite: CIV 420. (Cross reference: CIV 477)

CIV 543 Advanced Mechanics of Materials. (3 Hours) Study of beams under lateral load; beams with

combined lateral load and thrust; beams on elastic foundations; applications of Fourier series and virtual work principles to beam-type structures; stress and strain in three dimensions; applications to flexure of beams and plates; elements of the engineering theory of plates; and torsion of thin-walled open sections. Prerequisite: CIV 320 or permission of Department.

CIV 544 Advanced Design of Steel Structures. (3 Hours) Behavior and design of members subjected to fatigue, dynamic, combined loading. Methods of allowable design stress, and load resistance factor design. Design of continuous beams, plate girders, composite beams, open-web joists, connections, torsion and plastic analysis and design. Framing systems and loads for industrial buildings and bridges, design constraints and a major design project. Prerequisite: CIV 360. (Cross reference: CIV 476)

CIV 545 Design of Wood and Masonry Structures. (3 Hours) Engineering properties and behavior of wood for analysis and design of wooden beams, walls and diaphragms. Engineering properties and behavior of masonry for analysis and design of masonry walls, columns and shear walls. Framing systems and loads for multistory buildings, design constraints and a major design project. Prerequisite: CIV 420. (Cross reference: CIV 478)

CIV 550 Engineering Hydrology. (3 Hours) Principles and theory of surface water and groundwater flow and quality; understanding and determination of water budget, hydrologic cycle, Darcy's law, and water resources management at the watershed scale. Water quality parameters including data analysis and interpretation, laboratory tests, and maintenance of water quality. Applications in engineering design, Prerequisite: CIV 370 or permission of Department.

CIV 551 Advanced Fluid Mechanics. (3 Hours) Kinematics of fluid flow; plane irrotational and incompressible fluid flow; Navier-Stokes equations; two-dimensional boundary layers in incompressible flow; dimensional analysis and dynamic similitude; hydrodynamic stability; turbulence; real life problems; Engineering applications and system approach. Prerequisite: CIV 330 or permission of Department.

CIV 552 GIS Applications in Civil and Environmental Engineering. (3 Hours) This course introduces students to the basic concepts and skills necessary to engage applied Geographic Information Systems (GIS) with the field of Civil and Environmental Engineering. Students will gain basic theoretical knowledge required for development and successful use of GIS and practical training on use of GIS software. This course will consist of lecture sessions, lab exercises and GIS project. While the principles taught will be general in nature, the students will be taught how to use the ArcView GIS software program, and working through several exercises that emphasize its use in Civil and Environmental Engineering. Selected topics include: GIS analysis procedures, integration of survey control for data acquisition and rectification, hardware software selection criteria, and error propagation analyses, Global Positioning Systems (GPS) and their use with GIS. Prerequisite: permission of the Department.

CIV 553 Experimental Methods in Civil Engineering. (3 Hours) Introduction to experimental methods, instrumentation, data acquisition and data processing; experimental aspects of static and dynamic testing in the various areas of civil engineering; overview of laboratory work with several hands-on applications in the laboratory. Prerequisite: permission of Department.

CIV 554 Water Resources Engineering Planning and Management. (3 Hours). Managing water resources; the planning process, systems analysis methods; institutional framework for water resources engineering; comprehensive integration of engineering, economic, environmental, legal and political considerations in water resources development and management. Prerequisite: permission of the Department.

CIV 556 Groundwater Engineering. (3 Hours) Groundwater hydrology, theory of ground water movement, steady-state flow, potential flow, mechanics of well flow, multiple-phase flow, salt water intrusion, artificial recharge, groundwater contamination and models. Prerequisite: CIV 370 or permission of Department.

CIV 557 Computational Fluid Dynamics. (3 Hours) Finite-difference and finite-volume methods and basic numerical concepts for the solution of dispersion, propagation and equilibrium problems commonly encountered in real fluid flows; theoretical accuracy analysis techniques. Prerequisites: CIV 330 and knowledge of one programming language.

CIV 558 Sedimentation and River Engineering. (3 Hours) This course is developed for graduate students who plan to specialize in water resources/coastal engineering. Course covers hydraulics of sediment transport; mechanics of morphology, sediment budget concepts, mathematical modeling of sediment transport. Prerequisite: CIV 330 or Permission of Department.

CIV 559 Environmental Hydraulics. (3 Hours) The application of fluid mechanics principles in the analysis of environmental flows. Topics include: stratified flows, turbulent jets and plumes, wastewater and thermal diffusers, cooling ponds and cooling channels and the control of environmental problems. Prerequisites: CIV 330 or permission of Department.

CIV 560 Environmental Engineering II. (3 Hours) The physical, chemical, and biological environmental engineering systems that are used to protect health and the environment. Examples include drinking water treatment, wastewater treatment, hazardous waste treatment, and air pollution control. Prerequisite: permission of Department.

CIV 561 Chemistry for Environmental Engineering. (3 Hours) The principles of physical, equilibrium, inorganic, and organic chemistry as they apply to drinking water treatment, wastewater treatment, natural water quality, air quality, and air pollution control. Applications in engineering design. Prerequisite: CIV 340, or CIV 560, or permission of Department.

CIV 562 Hazardous Waste Engineering. (3 Hours) Comprehensive study of the complex, interdisciplinary engineering principles involved in hazardous waste handling, collection, transportation, treatment, and disposal. Also covered are waste minimization, site remediation, and regulations important for engineering applications. Design constraints, engineering judgment, and ethical responsibility are covered. Contemporary hazardous waste issues and urban issues are also addressed. Prerequisite: CHEM 241, CHML 241, CIV 340, CIVL 340, or permission of Department. (Cross reference: CIV 468)

CIV 563 Microbiology for Environmental Engineering. (3 Hours) The microbiological principles that apply to wastewater treatment, drinking water protection, water quality, and disease transmission. Applications in engineering design. Prerequisite: CIV 560 or permission of Department.

CIV 564 Surface Water. (3 Hours) Water quantity, water quality, regulation of, and management of rivers, lakes, and wetlands. Applications in engineering design. Prerequisite: permission of Department.

CIV 565 Wetland Management for Environmental Engineering. (3 Hours) The physical, chemical, biological, and regulatory aspects of wetland ecosystems. The impacts of engineered structures on wetland systems, and the factors involved with developing specifications for wetland creation and restoration. Prerequisite: permission of Department.

CIV 566 Air Pollution and Control. (3 Hours) The sources of and engineering principles to prevent or control air pollution and to design and operate processes. Topics include the risks of air pollution to which the public is exposed, the principle and factor underlying the generation of pollutants, physical principles describing how pollution affects the atmosphere and human well-being, regulations which engineers will be expected to understand and comply with. The engineering aspects including principles governing pollutant production from stationary and mobile combustion systems, modeling of the generation and transport of pollutants in the atmosphere, methods for separation and removal of gases and particulates from a process gas stream. Prerequisite: permission of Department.

CIV 567 Environmental Remediation. (3 Hours) The course covers current engineering solutions for the remediation of soils and waters contaminated by hazardous waste or spills. The technologies to be covered include bioremediation, oxidation, soil vapor extraction, soil washing, surfactant-enhanced remedy, thermal treatment, air stripping, solidification/ stabilization, electro kinetic decontamination, underground barriers, permeable reactive treatment walls, and other newly-emerging technologies. The engineering principles behind the remediation technologies are emphasized. Examples of successful applications of the remediation technologies are discussed. Prerequisite: permission of Department.

CIV 568 Land Disposal of Waste. (3 Hours) Theoretical, regulatory, and practical aspects of the disposal of waste on lands. Decontamination and reclamation of lands contaminated by industrial activities and spills of industrial chemicals. The usefulness and environmental impact of the disposal of municipal and industrial wastes via land treatment and land filling. Design considerations and engineering problems associated with the land disposal of septic tank effluent, municipal garbage, sewage sludge, sewage effluent, industrial and hazardous waste, and radioactive wastes. Prerequisite: permission of Department.

CIV 569 Environmental Systems Modeling. (3 Hours) Mathematical modeling of environmental systems, including rivers, lakes, estuaries, and air. Prerequisite: permission of Department.

CIV 570 Regional Geological Engineering. (3 Hours) Geological engineering problems unique to specific geomorphic and physiographic regions based on terrain, rock type, and geologic structure will be addressed. Examples will be presented to show how site-specific conceptual geologic models are necessary for successful engineering design in unique geologic regions of the United States. Prerequisite: permission of Department.

CIV 571 Principles of Geoenvironmental Engineering. (3 Hours) Topics in geoenvironmental engineering in an urban environment, landfill design and incineration options. Stability of landfills, geotechnical characteristics of landfills, liner systems. Waste characterization, minimization, collection, treatment, transport and disposal. Leachate characteristics and potential groundwater contamination, design constraints. Legal and ethical considerations. Prerequisite: permission of Department. (Cross reference: CIV 471)

CIV 572 Applied Geotechnical Engineering Design. (3 Hours) Practical real life urban projects and advanced laboratory experience in geotechnical engineering, construction dewatering, construction issues, safety and economy, urban geotechnical engineering issues, preparation of subsurface investigation and geotechnical engineering reports, ethical considerations, oral presentation. Pre or co-requisite: CIV 430 or permission of Department. (Cross reference: CIV 472)

CIV 573 Environmental Geology for Engineers. (3 Hours) Defines the role of Environmental Geology in the engineering design of remedial activities dealing with a wide range of geotechnical engineering problems. Fundamental concepts of environmental unity and the rising human population will be addressed. Topics will range from earthquakes to coastal processes with particular emphasis on landslides and water problems. Prerequisite: permission of Department.

CIV 574 Engineering Hydrogeology. (3 Hours) Defines the role of Hydrogeology in the engineering design of activities dealing with the interaction of ground and surface water. The course will address a wide range of topics including the role of water in earthquakes and landslides, land subsidence, swelling clay foundations, geothermal energy, engineered wetlands, cave and karst formation, contaminant

transport, and water resources with emphasis in engineering design. Prerequisite: permission of Department.

CIV 575 Applied Geological Engineering. (3 Hours) Applications of geological concepts including geomorphology and structural geology in solving geological engineering problems. Study of engineering principles and properties of earth materials. Exploration during engineering design and methods of site investigations. Applications of instrumentation and equipment used for soil, rock, and water analyses. Prerequisite: permission of Department.

CIV 576 Geological Engineering Analysis. (3 Hours) Computer applications to geological engineering, analysis, design, and use of computers for geological engineering projects. Computer-aided engineering facilities and use of general productivity and engineering software. Numerical methods in the solution of geological engineering and related problems. Case study of a complex project and a large-scale engineering analysis. Prerequisite: permission of Department.

CIV 577 Air-Photo Interpretation for Terrain Evaluation. (3 Hours) Determination of soil, bedrock, and drainage characteristics of land areas by air-photo interpretation and analysis; physical characteristics of landforms; application of air-photo interpretation for engineering soil surveys, land use suitability evaluation, and land use planning, applications in engineering design. Prerequisite: permission of Department.

CIV 578 Applied Geophysics. (3 Hours) Gravity and magnetic theory and methods. Gravitational field of earth and gravity measurements applications to geological engineering problems. Imaging subsurface features of earth using basic principles of physics, namely elastic, electric, magnetic, and density properties of earth material. Applications in engineering design. Prerequisite: permission of Department.

CIV 579 Engineering Seismology. (3 Hours) Theory and applications in earthquake seismology, earthquake mechanics, wave propagation, earth structure, instrumentation, interpretation of seismograms, focal mechanisms, faults, paleoseismology, seismotectonics, earthquake locations and magnitudes, selection of ground motion parameters. Applications in engineering design. Prerequisite: permission of Department.

CIV 631 Linear Theory of Ocean Waves (3 Hours): Governing equations in free surface flow, deterministic and probabilistic wave theories, wave transformation, wave-induced coastal currents. The formulation and solution of the governing boundary value problem for small amplitude waves are developed and the kinematic and pressure fields for short and long waves are explored. Prerequisite: CIV 330 or Permission of Department

CIVL 631 Linear Theory of Ocean Waves' Laboratory. (1 Hour) Laboratory for linear ocean wave theory generation and propagation of linear waves, measurement of wave properties and observation of wave transformations in shallow water.

CIV 632 Tides and Long Waves. (3 Hours) A systematic development of the theory of ocean tides, tidal forcing functions, near shore tidal transformations and tidal propagation in harbors and estuaries. An introduction to the response of harbors to long waves and the study of the generation of long ocean waves. Prerequisite: permission of the Department

CIV 633 Airport Planning and Design. (3 Hours) Basic principles of airport facilities design to include aircraft operational characteristics, noise, site selection, land use compatibility, operational area, ground access and egress, terminals, ground service areas, airport capacity, and special types of airports. Prerequisite: CIV 390 or permission of Department.

CIV 636 Spectral Wave Analysis (3 Hours) Measurement techniques of ocean waves. Introduction and basic concept of wave spectrum. Harmonic analysis and mathematical formulation of wave spectrum. Maximum entropy and maximum likelyhood methods. Idealized wave spectral models. Wave energy balance equation and its applications. Nonlinear wave-wave interaction and diffraction. Wave hindcast and forecast modeling in coastal waters. Prerequisite: CIV 330, CIV 631 or permission of the Department.

CIV 637 Advanced Design for Breakwater Rehabilitation, (3 Hours) Advanced analysis and design considerations for breakwaters are investigated for the most complex challenges. These challenges are associated with rehabilitation and/or reconstruction of damaged breakwaters. Design considerations are explored from an analysis of breakwater failures at Sines, Nawilliwilli, Kahului and others. Toe design, crest elevation, crown design, core alternatives, runup, overtopping, design waves, head design, constructability and functionality are explored. Prerequisite: permission of Department

CIV 640 Finite Element Methods. (3 Hours) Theory and application of the finite element method; stiffness matrices for triangular, quadrilateral, and isoparametric elements; two- and three-dimensional elements; algorithms necessary for the assembly and solutions; direct stress and plate bending problems for static, nonlinear buckling and dynamic load conditions; displacement, hybrid, and mixed models together with their origin in variational methods. Prerequisite: CIV 540 or permission of Department.

CIV 642 Prestressed Concrete Design. (3 Hours) Study of strength, behavior, and design of prestressed reinforced concrete members and structures, with primary emphasis on precast, prestressed construction; emphasis on the necessary coordination between design and construction techniques in prestressing. Prerequisite: CIV 420 or permission of Department.

CIV 645 Plates and Shells. (3 Hours) Classical bending theory of plates and shells; emphasis on methods of solution including series expansions, finite element and finite difference methods; application of theories to commonly encountered structures in practice; and consideration of in plane loads, large deflections, buckling, and anisotropy. Prerequisite: CIV 640 or permission of Department.

CIV 650 Small Watershed Hydrology. (3 Hours) The role of land conditions in dealing with engineering problems of applied hydrology with emphasis on the small watershed, limited data, and land management situations; gain a physically-based understanding of hydrologic processes that define the functions of small watersheds; Effects of natural and human disturbances on the components of the hydrologic cycle; Investigate special characteristics of small watersheds; Approaches for dealing with limited data; Use the understanding of applied hydrology to predict the impacts of various land use activities on terrestrial and aquatic ecosystems; Develop analytic tools to integrate land use and catchment characteristics to predict catchment response and guide watershed management. Topics include stream flow generation, hill slope hydrology, stream channel hydraulics, hydrograph separation, evapotranspiration, hydrologic tracers, riparian zone hydrology, and hyporheic zone hydrology. Applications in engineering design. Prerequisite: CIV 550 or permission of Department.

CIV 652 Hydraulic Engineering Design. (3 Hours) Design of water supply and transport systems; Design and analysis of structures for controlling and conveying water in both the built and natural environment; Engineering applications of hydraulic and hydrologic engineering; Analytic methods and computer models for the design and evaluation of water resource projects such as flood control and river basin development; Common models, and typical applications for water resource systems; Reservoir design, flood routing; and design of water distribution and storm water management systems, and sanitary sewers. Prerequisite: CIV 370 or permission of Department.

CIV 653 Advanced Design of Hydraulic Structures. (3 Hours) Analysis and characteristics of flow in open channels (natural and artificial); channel design considerations including uniform flow (rivers, sewers), flow measuring devices (weirs, flumes), gradually varied flow (backwater and other flow profiles, flood routing), rapidly varied flow (hydraulic jump, spillways), and channel design problems (geometric considerations, scour, channel stabilization, sediment transport); analysis and design of hydraulic structures such as dams, spillways etc. based on economic, environmental, ethical, political, societal, health and safety considerations. Prerequisite: CIV 370 or permission of Department. (Cross-Reference: CIV 466)

CIV 654 Water Resource Systems Engineering. (3 Hours) Linear and non-linear optimization models and simulation models for planning and management of water systems; single- and multi-objective analysis and deterministic and stochastic techniques. Prerequisites: CIV 554 or permission of the Department.

CIV 655 Stochastic Hydrology. (3 Hours) Advanced applications of statistics and probability to hydrology, time series analysis and synthesis, and artificial neural network methods. A combination of theory and application to the field of hydrology, environmental and water resource engineering, climatic modeling and other natural resources modeling. Prerequisites: CIV 550, MATH 307 or permission of the Department.

CIV 659 Advanced Topics in Water Resource Engineering. (Variable 1-4 Hours) Course will focus on a variety of topics in the field of water resources engineering. May be repeated for credit. Prerequisite: Permission of the Department.

CIV 660 Physicochemical Processes in Water and Wastewater Treatment. (3 Hours) Fundamental principles, analysis, modeling, and design considerations of physical and chemical processes for water and wastewater treatment processes and operations. Drinking water treatment processes will be focused on while parallel wastewater treatment schemes also being discussed. Relevant water quality characteristics, standards, and regulations in engineering design will be reviewed. Prerequisite: CIV 561 or permission of Department.

CIV 661 Biological Processes in Wastewater Treatment. (3 Hours) Theory and applications of the biological processes available for the treatment of wastewaters. Fundamentals of biological degradations and transformation of pollutants. Microbial growth kinetics and modeling. Wastewater treatment processes, both aerobic and anaerobic, including suspended growth biological processes and attached growth processes. Emphasis on engineering design considerations and parameters. Prerequisite: CIV 660.

CIV 663 Design of Environmental Engineering Facilities. (3 Hours) Analysis and design considerations and constraints for environmental engineering facilities such as water and wastewater treatment plants, solid and hazardous waste landfills, and resources recovery facilities. Design of municipal wastewater treatment plant including site selection, plant layout, hydraulic profile, preliminary treatment processes (screening, sedimentation, flow equalization, etc.), secondary treatment processes (activated sludge, trickling filter), waste stabilization ponds/constructed wetland), and sludge treatment and disposal (thickening, centrifugation, belt press, anaerobic digestion, thermal process and land disposal). Completion of one major design project and two minor design projects. Prerequisite: CIV 661 or permission of Department. (Cross reference: CIV 460)

CIV 664 Limnology for Environmental Engineering. (3 Hours) The study of aquatic ecosystems, with an emphasis on lakes. The physical characteristics of water and lakes; the chemical characteristics of aquatic systems; the dominant plants and animals in lakes, streams, and wetlands. The impacts of pollution, engineered structures, and man-made alterations of lakes and streams. Prerequisite: permission of Department.

CIV 665 Environmental Law. (3 Hours) The major federal statutes and regulations that govern environmental protection. Included are the National Environmental Policy Act, the Clean Air Act, the Clean Water Act, Superfund, and others. Prerequisite: permission of Department.

CIV 666 Advanced Waste Treatment Processes in Environmental Engineering. (3 Hours) An in-depth study of the biological processes used to treat wastewater, with an emphasis on recently published

information. Prerequisite: CIV 661 or permission of Department.

CIV 667 Biological Process Engineering. (3 Hours) Applications of the principles of microbial kinetics and heat transfer to the analysis and design of biological engineering processes. Emphasis on applications in environmental engineering processes or projects. Prerequisite: permission of Department.

CIV 668 Bioenvironmental Engineering. (3 Hours) Engineering principles for the design of systems for the biological treatment and utilization of organic by-products from animal and crop production and from industrial processes such as food and crop processing industries. Design of best management practices to protect bioenvironmental resources by minimizing non-point pollution (off-site movement of sediment, nutrients and other constituents) and by minimizing nuisance odors associated with land applied organic residues, inorganic fertilizers and pesticides. Economic utilization of beneficial components of typical wastes. Prerequisite: permission of Department.

CIV 669 Advanced Topics in Environmental Engineering. (Variable 1-4 Hours) Course will focus on a variety of topics in the field of environmental engineering. May be repeated for credit. Prerequisite: permission of Department.

CIV 670 Rock Mechanics. (3 Hours) Classification of rock masses, stress and strain in rock, elastic and time-dependent behavior of rock, state of stress in rock masses, failure mechanisms, construction applications, geological and engineering applications. Prerequisite: permission of Department.

CIV 671 Advanced Topics in Geological Engineering. (Variable 1-4 Hours). Course will focus on a variety of topics in the field of geological engineering. May be repeated for credit. Prerequisite: permission of Department.

CIV 672 Advanced Geomechanics. (3 Hours) Theoretical and quasi-theoretical approaches for advanced soil mechanics including stress analysis, consolidation theory, immediate settlement, and saturated and partially saturated soils; problem idealization; introduction to rock mechanics; engineering judgment. Prerequisite: CIV 380 or permission of Department.

CIV 673 Advanced Foundation Engineering. (3 Hours**)** Advanced topics in foundations design, special cases of shallow foundations; horizontal load capacity of pile foundations; battered piles, load calculation of pile groups. Drilled caissons; design and construction of sheet piles including cantilever and anchored sheet piles; earth pressures and stability of retaining structures; design of braced supports, cofferdams; design examples. Prerequisite: CIV 430 or permission of Department.

CIV 674 Soil Dynamics. (3 Hours) Study of soil behavior under various dynamic loadings including earthquakes. Laboratory & field techniques for determining dynamic soil properties and liquefaction potential. Factors affecting liquefaction; dynamic soil-structure interaction. Engineering design examples. Prerequisite: CIV 380 or permission of Department.

CIV 675 Earth Dams and Slopes. (3 Hours) Stability of natural and man-made slopes under various loading conditions, slope protection. Selection and measurement of pertinent soil parameters. Engineering design and construction of earth dams and embankments. Practical aspects of seepage effects and ground water flow. Flow net and its use; wells; filters; total and effective stress methods of slope analysis. Prerequisite: CIV 380 or permission of Department.

CIV 676 Tunneling. (3 Hours) Overview of tunneling practice in rocks and soft ground. Underground construction techniques. Geological aspects and major technical problems in tunneling. Various tunneling methods and selections. Design and support of tunnels in soft ground and rock. Prerequisite: Permission of Department.

CIV 677 Design and Construction with Geosynthetics. (3 Hours) Properties and behavior of geosynthetics including geotextiles, geogrids and other fabrics; applications in geotechnical and geo-environmental engineering; quantify hydraulic behavior; applications in remediation, retaining structures, and foundations construction. Prerequisite: permission of Department.

CIV 678 Soil Bioengineering. (3 Hours) Engineering practices and ecological principles for the assessment, design, construction and maintenance of living vegetation systems. Slope stabilization against shallow mass movement and erosion through vegetated reinforcement. Root reinforcement, erosion control, aesthetics and environmental factors in engineering design are considered. Prerequisite: permission of Department.

CIV 679 Advanced Topics in Geotechnical Engineering. (Variable 1-4 Hours) Course will focus on a variety of topics in the field of geotechnical engineering. May be repeated for credit. Prerequisite: permission of Department.

CIV 680 Unsaturated Soil Mechanics. (3 Hours) Introduction of unsaturated soil, stress-state variables, soil water suction and soil water characteristic curves, hydraulic function curves, flow in unsaturated soil, shear strength and slope stability analysis, lateral earth pressure and retaining structures design, and compressibility and volume change analysis for unsaturated soils. Prerequisites: CIV 380 or Departmental Permission.

CIV 681 Excavation Support Systems and Retaining Structures. (3 Hours) Earth pressure theory used in the design of temporary and permanent earth retaining structures, guidelines for the selection of retention method, retaining wall design and associated construction issues of gravity walls, concrete retaining walls, MSE wall, sheet pile wall, soldier pile and diaphragm walls, braced and tie back excavation support systems. Prerequisites: CIV 380 or permission of Department.

CIV 682 Computational Geotechnics. (3 Hours) Introduction to numerical and finite element modeling, analyses of embankments, earth dams, slopes, excavation support systems including soldier pile and

diaphragm walls, shallow and deep foundation systems, and other geo-structures using advanced geotechnical software. Prerequisites: CIV 380 or permission of Department.

CIV 683 Soil Structure Interactions. (3 Hours) Introduction to geotechnical earthquake engineering and fundamental understanding of soil behavior under dynamic loading, finite element analysis of soil structure interaction due to dynamic loading and structural response, seismic slope stability analysis, seismic design of retaining wall and buried structures, case studies. Prerequisites: CIV 380 or permission of Department.

CIV 684 Advanced Site Characterization and Instrumentation. (3 Hours) In situ test methods, advantages and limitations, SPT, CPT, DCPT, CPTU or piezocone, DMT, pressure meter, shear vane and other field test methods, non-destructive seismic, resistivity, electromagnetic methods, soil property interpretation procedures, geotechnical instrumentation types, monitoring and applications. Prerequisites: CIV 380 or permission of Department.

CIV 695 Scientific Writing Seminar. (1 Hour) Exercises in scientific writing format and style, with particular emphasis on writing abstracts and manuscripts for publication in referred archival journals.

CIV 696 Seminar. (1 Hour) Presentation of papers, projects and reports by visiting lecturers, graduate students, engineers, and community leaders.

CIV 697 Internship. (Variable 1-3 Hours) Supervised graduate internship and externship in various areas. Prerequisite: permission of Department.

CIV 698 Independent Study. (Variable 1-4 Hours) Intensive study of a special engineering project including research and literature review selected in accordance with student interests and arranged in consultation with the adviser. Topics will vary. Student will make periodic reports, and will prepare a scholarly paper at the end of semester. Prerequisite: permission of Department.

CIV 699 Thesis Research. (Variable 1-6 Hours) Master's thesis representing an independent and original research. Prerequisite: permission of adviser.

CIV 899 Dissertation Research. (Variable 1-6 Hours) Dissertation representing independent and original research.

CPE Courses

CPE 500 Software Engineering. (3 Hours) Examination of the software development life cycle; requirements elicitation; system design; Unified Modeling Language (UML) focus on design; risk analysis; configuration management; testing; maintenance; software project management; team building.

CPE 502 Telecommunication Software Design. (3 Hours) Comprehensive course to familiarize telecommunication professionals with the state of the art in software concepts and technologies in modern telecommunications applications; examination of state-of-the-art software concepts and technology in modern telecommunications applications; focus on software process modeling as applied to telecommunications; application of software engineering concepts and processes; user interface design; reusability; reuse; reliability; distributed computing; real-time operating systems; interfacing with Optical/IP Networks; Personal Communication Service (PCS); switch control; heavy emphasis on real world application topics including Optical/IP Network, Intelligent Network (IN) Service Creation, and Cellular/Personal Communication Service (PCS).

CPE 503 Computational Methods. (3 Hours) Computational methods for solving problems in engineering analysis; variational methods; finite-difference analysis; optimization methods; finite-difference analysis; matrix methods; focus is on real-world engineering problems; techniques and algorithms for simulating large-scale digital and analog circuits.

CPE 505 Analysis of Algorithms. (3 Hours) Mathematical foundations of algorithms and algorithm analysis; sorting and searching algorithms, graph algorithms, algorithm design techniques, lower bound theory, fast Fourier transforms, NP-completeness.

CPE 508 Operating Systems. (3 Hours) Examination of concepts of process communication and synchronization; protection; performance measurement; study of mutual exclusion; concurrent processes; device and memory management; I/O and interrupt structures.

CPE 512 Computer Architecture. (3 Hours) Study of architectural features of modern processors, including cache memories and memory systems, pipeline designs, branch prediction techniques; design of superscalar, multithreaded VLIW processors, code optimization for such systems will be studied; quantitative evaluation of architectural features.

CPE 515 Advanced Logic Design. (3 Hours) Advanced concepts in Boolean algebra; use of hardware description languages as a practical means to implement hybrid sequential and combinational designs; digital logic simulation; rapid prototyping techniques; design for stability concepts; focuses upon the actual design and implementation of sizeable digital design problems using a representative set of Computer Aided Design (CAD) tools.

CPE 520 Advanced Engineering Analysis I. (3 Hours) A comprehensive course to familiarize engineering professionals with advanced applied mathematics as it relates to solving practical engineering problems. The course of intensive study blends the theoretical underpinnings of advanced applied mathematics with an understanding of how these powerful tools can be used to solve practical engineering problems. The material covered includes Ordinary Differential Equations; Linear Algebra, Vector Calculus; Fourier Analysis and Partial Differential Equations.

CPE 521 Advanced Engineering Analysis II. (3 Hours) A comprehensive course to familiarize

engineering professions with advanced applied mathematics as it relates to solving practical engineering problems. The course of intensive study blends the theoretical un of advanced applied mathematics with an understanding of how these powerful tools can be used to solve practical engineering problems. The material covered includes Complex Analysis; Numerical Methods; Optimization; Graphs; and Probability and Statistics.

CPE 530 VLSI Design. (3 Hours) Theory of MOS transistors: fabrication, layout, characterization; CMOS circuit and logic design; circuit and logic simulation, fully complementary CMOS logic, pseudo-NMOS logic, dynamic CMOS logic, pass-transistor logic, clocking strategies; sub system design; ALUs, multipliers, memories, PLAs; architecture design: data path, floor planning, iterative cellular arrays, systolic arrays; VLSI algorithms; chip design and test; full custom design of chips, possible chip fabrication by MOSIS and subsequent chip testing.

CPE 531 VLSI Testing and Design for Testability. (3 Hours) Introduction to testing of digital electronic circuits and systems; faults and fault modeling, test equipment, test generation for combinational and sequential circuits, fault simulation, memory and microprocessor testing, design for testability, built-in self-test techniques, and fault location.

CPE 532 Digital Integrated Circuit Design. (3 Hours) Design methodologies for digital systems using a modern hardware description language; algorithmic, architectural and implementation aspects of arithmetic processing elements; design of Complex Instruction Set (CISC), Reduced Instruction Set (RISC), and floating point processors; synthesis, simulation and testing of processors with computer-aided design tools.

CPE 533 Fault-Tolerant Computing Systems. (3 Hours) Analysis and design of very high reliability and availability systems; fault types, reliability techniques, and maintenance techniques; case studies of high-availability long-life, life-critical systems; both hardware and software techniques for achieving fault-tolerance will be studied.

CPE 534 Coding Theory. (3 Hours) Introduction to linear codes; error detection and correction; bounds on the error correction capabilities of codes; Hamming distance code; linear block codes; syndrome decoding of linear block codes; cyclic codes; error trapping; decoding; burst error correcting codes; convolutional codes with threshold, sequential and viterbi decoding; cyclic random error correcting codes; P-N sequences; cyclic and convolutional burst error correction codes; other coding conceptions and implementations.

CPE 536 Solid State Electronics. (3 Hours) This course explores the electronic properties of semiconductor and related materials used in modern day devices. For common semiconductor devices, operation, electrical characteristic, manufacturing and applications are covered.

CPE 539 Lasers. (3 Hours) Review of electromagnetic theory; ray tracing in an optical system; Gaussian beam propagation; resonant optical cavities; study of excitation and laser mechanisms in gas and semiconductor lasers.

CPE 540 Telecommunication Systems. (3 Hours) Preparatory course for all subsequent graduate work in telecommunications; theoretical and technical foundation for the analysis and design of communications systems; use of classical and modern mathematical analysis techniques, including Fourier Series and Fourier Transform; classical modulation techniques (amplitude, frequency, phase).

CPE 541 Computer Networks. (3 Hours) Study of computer network architectures, protocols, and interfaces; OSI reference model; Internet architecture; networking techniques (multiple access, packet/cell switching, and internetworking); end-to-end protocols; congestion control; high-speed networking; network management.

CPE 542 Computer and Network Security. (3 Hours) In-depth examination of computer and network security; coverage of encryption, public/private keys, certificates, security of wired and wireless communication systems; invasion and intrusion techniques and detection; security architectures; network and computer risk analysis; biometrics and their application to computer security will be examined.

CPE 543 Wireless Communication Systems. (3 Hours) Principles of mobile communication systems; models of wave propagation; compensation for fading; modulation, demodulations; coding, encoding; multiple-access techniques; performance characteristics of mobile systems; wireless device characteristics; low-power mobile devices; wireless communication system design; mobile and cell antenna designs.

CPE 544 Electromagnetic Field Analysis. (3 Hours) Maxwell's equations; solutions of Laplace's equation; Green's Function; scalar and vector potentials; energy and momentum in electromagnetic fields; interaction of fields and material media.

CPE 545 Antennas. (3 Hours) Examine the theory and properties of various communication antennas covering the range from RF frequencies to millimeter wavelengths; examine actual antennas and their characteristics.

CPE 546 Digital Communication Systems. (3 Hours) Maxwell's equations; numerical propagation of scalar waves; numerical implementation of boundary conditions; absorbing boundary conditions for free space and waveguides; selected applications in telecommunications, antennas, microelectronics, digital systems.

CPE 547 Modeling and Analysis of Computer and Communication Systems. (3 Hours) Modeling of single and multiprocessor systems, single and multi-stage interconnection networks, computer networks; analysis using Stochastic processes, Markov and Queuing techniques; modeling using Petri Nets and Finite State models.

CPE 551 Digital Signal Processing. (3 Hours) Signals and systems; sampling continuous-time signals and reconstructions of continuous-time signals from samples; spectral analysis of signal using the discrete

Fourier transform; the fast Fourier transform and fast convolution methods; z-transforms; finite and infinite impulse response filter design techniques; signal flow graphs and introduction to filter implementation.

CPE 552 Computer Vision. (3 Hours) Examination of information processing approaches to computer vision; algorithms and architectures for artificial intelligence and robotic systems capable of vision; inference of three-dimensional properties of a scene from its images, such as distance, orientation, motion, size and shape, acquisition and representation of spatial information for navigation and manipulation in robotics.

CPE 555 Control Systems. (3 Hours) Analysis and design of control systems with emphasis on modeling and dynamic response; transform and time domain methods for linear control systems; stability theory; root locus, bode diagrams and Nyquist plots; design specification in time and frequency domains; state-space design with computer solutions; compensation design in the time and frequency domain; modern design principles.

CPE 556 Systems Theory. (3 Hours) Linear operators; impulse response including convolution; transition matrices; fundamental matrix; linear dynamical system; definition; representation; diagramming principles; signal flow diagramming; analog and digital modeling; controllability and observability; eigenstructure; similarity transformations.

CPE 557 Robotics. (3 Hours) Fundamentals of robotics; rigid motions; homogenous transformations; forward and inverse kinematics; velocity kinematics; motion planning; trajectory generation; sensing; vision; and control.

CPE 560 Embedded Design with Microprocessors. (3 Hours) Microcomputer system design and use of microprocessors and single chip microcomputers as basic system components; basic microcomputer design and the interface between microprocessor and external devices; course examines the software aspects of microcomputers using assembly language and C programming; single chip microcomputers for embedded and power efficient applications; direct memory access, memory design and management, cache memory, fault tolerance issues, parallel processing with emphasis on hardware issues.

CPE 571 Engineering Foundations of Biomedical Engineering. (3 Hours) This course is designed for engineering graduate students who come from traditional engineering disciplines and provides a comprehensive survey of the multi-disciplinary field of biomedical engineering. This course is intended to provide a broad perspective of the role that biomedical engineers play and to serve as an engineering foundation for subsequent, more advanced courses in biomedical engineering. Prerequisite: permission of Department

CPE 573 Biomedical Instrumentation. (3 Hours) Origins and characteristics of bioelectric signals, recording electrodes, amplifiers, chemical, pressure and flow transducers, noninvasive monitoring techniques, and electrical safety. Prerequisite: CPE 571

CPE 575 Biomaterials. (3 Hours) Introductory course in biomaterials. Topics include structure property relationships for synthetic and natural biomaterials, biocompatibility, and uses of materials to replace body parts. Perquisite: CPE 571

CPE 601 Code Optimizations. (3 Hours) Discussion of methods to improve the performance of code generated by compilers; data-flow and dependence analysis, peep-hole optimization, instruction scheduling, and parallelism enhancing transformations; techniques to improve the utilization of registers, instruction level parallelism, and memory hierarchies in modern computer systems.

CPE 610 Parallel Computing and Programming. (3 Hours) Introduction to processing in parallel and distributed computing environments; general concepts of parallel machine models, processes, mutual exclusion, process synchronization, messing passing, and programming languages for parallel computing and scheduling; design and analysis of parallel algorithms; performance analysis of parallel algorithms; parallel programming environments: P threads for shared memory multiprocessor systems and PVM/MPI for distributed networks computers.

CPE 611 Computer Arithmetic. (3 Hours) Theory and application of computer arithmetic, design, and analysis of computer arithmetic units: fast adders, fast multipliers, shifters, dividers, and floating-point arithmetic units.

CPE 618 High Performance Computing (3 Hours) The class will study a variety of algorithms, their applications, and tradeoffs between different solutions. There will be discussions on topics such as parallel computer architectures (memory hierarchy, interconnection networks, latency, bandwidth, parallel I/O), and software systems, with the aim of understanding their capabilities, costs and limitations. Students will make use of recent technology through a number of software packages and programming environments appropriate to the topics addressed. High performance computing tools will be used to compare and evaluate the performance of different implementations through a variety of criteria. Students will draw conclusions regarding preferred algorithms, programming paradigms, and programming environments and tools for parallel and distributed computing.

CPE 630 Design Automation of VLSI Systems. (3 Hours) Theory and algorithms for design automation, design automation tools in VLSI systems, Advanced VSLI design principles, Verilog and VHDL hardware description languages; timing-driven physical design and synthesis, circuit simulation and validation, formal verification, design for reuse and System on Chip (SOC) design methodology.

CPE 635 Advanced Circuit Theory. (3 Hours) CMOS technology; structured digital circuits; VSLI systems; computer-aided design automation tools and theory for design automation; chip design and integration; microelectronic systems architecture;

VLSI circuit testing methods; advanced high-speed circuit design and integration.

CPE 640 Computer Security. (3 Hours) Comprehensive introduction to field of computer security; security architectures; physical security; communications security; system security; operational security; network and computer risk analysis; invasion and intruder techniques; case studies; in-depth examination of cryptography; biometrics and their application to computer security will be examined.

CPE 641 Advanced Computer Networks. (3 Hours) Concepts and fundamental design principles of computer networks and Internet that have contributed to modern network implementations; survey of new trends in networks and Internet/intranet with design of real networks; topics include discussion of fundamental aspects of Internet application layer (HTTP, FPT, DNS), TCP/UDP socket programming, reliable data transfer, congestion control; network layer (IPv4 and IPv6) and routing; link layer and Local Area Networks (LAN); multimedia networking (RTSP, RPT, RSVP, DiffServ); security in computer networks.

CPE 642 Computer Network Security. (3 Hours) Principles and concepts in computer network security; introduction to cryptography, confidentiality, authentication, digital signatures, E-mail security, IP security, Web security, intruders, intruder detection, malicious software, firewalls, biometrics as applied to security, and other network security-related issues.

CPE 643 Wireless Networks. (3 Hours) Wireless architectures and networking; examination of both wireless LANs and mobile wireless networks; wireless network protocols; channel and resource allocation; mobile IP; wireless data management; Quality of Service (QoS); performance modeling; related wireless networking topics; examination of various architectures and standards (802.11, 802.15, 802.16), IR, and other related protocols.

CPE 644 Optical Communication Systems. (3 Hours) Principles of optical communication systems and fiber optic communication technology; characteristics of optical fibers, laser diodes, and laser modulation; laser and fiber amplifiers; detection; demodulation; dispersion compensation; system typologies.

CPE 645 Microwave Circuits and Systems. (3 Hours) Operating principles of devices at microwave and millimeter wave frequencies; sources; detectors; waveguide; cavities; antennas; scattering parameters; impedance matching; system design.

CPE 646 Global Positioning Systems and Location Services. (3 Hours) Examination of satellite navigation systems; overview of transition from radio navigation systems to modern satellite-based systems; examination of satellite signal propagation, clock accuracy, and injected errors and their effect on accuracy; application of GPS and location services as related to autonomous mobile vehicles and public safety; examination of alternative location services and their comparison to GPS.

CPE 647 Mobile Computing Systems. (3 Hours) Overview of the emerging field of mobile computing; land mobile vs. satellite vs. in-building communications systems; RF vs. IR; cellular telephony; mobility support in cellular teleTelephone networks; Personal Communications Systems/ Personal Communications Networks; wireless local area networks; direct broadcast satellite; low earth orbiting satellites; examination of data management, reliability issues; mobile IP; end-to-end communication; channel and other resource allocation; routing protocols; 2G and 3G standards and protocols such as TDAM, CDMA, GMS, PCS will be discussed.

CPE 648 Wireless Sensor Networks. (3 Hours) Survey of the field of wireless communications as related to low-power embedded sensor networks including communications standards and protocols, e.g. 802.11, Bluetooth, 802.15.4/Zigbee; examination of network services including reliable delivery, routing, naming, and security; examination of system architectures, operating systems and language support, distributed algorithms, and applications for wireless sensor networks; target tracking, data collection and analysis, power and resource management; a sensor network is implemented during the course.

CPE 649 Telecommunications Network Management (3 Hours) Systematic examination of standards, basic concepts, current practices in telecom system management; Telecommunications Network Management (TNM) and OSI coverage; coverage of major telecom management standards; examination of management issues relating to both wireless mobile networks and traditional telecom systems, coverage of essential features of TNM architectures; examination of management of telecommunication network equipment and services; interoperability in a multi-supplier environment.

CPE 655 Advanced Control Systems. (3 Hours) Linearization of nonlinear systems; phase-plane analysis; Lyapunov stability analysis; adaptive estimation; stability of adaptive control systems.

CPE 670 Wireless Design Laboratory. (3 Hours) Laboratory experiments directed towards in-depth understanding of the implementation of components used in wireless communications; practical experience in the use of Bluetooth, WiFi, 802.11, and RF related components and networks.

CPE 671 3G and 4G Wireless Networks. (3 Hours) Examination of the technical, business, and regulatory issues surrounding third and fourth generation (3G and 4G) wireless communication systems; examination of the evolution of the various generation of wireless communications; focus on CDMA, Wideband CDMA, 3G, GSM, 4G designs and applications; extensive use of case studies; examination of both protocols and physical implementations.

CPE 672 Network Quality Assurance and Simulation. (3 Hours) Focus on the theoretical and practical aspects of network simulation and quality assurance; fundamentals of simulation and statistical modeling; random variable distributions; random number generation; wireless network performance; distributed systems; distributed and parallel systems and services; resolution in simulation; modeling and

abstraction in multilevel simulation; distributed simulation consideration; implementation of actual network simulation and modeling project.

CPE 673 Wireless Internet Applications Development. (3 Hours) Course focuses on the Wireless Application Protocol (WAP) and the Wireless Markup Language (WML), Microsoft Mobile .Net framework, Java Server Pages, Active Server Pages, CGI, and related protocols; attention is directed to development of applications using both thin and thick client models; course is composed of development of applications using both simulators and actual application servers and wireless devices such as WAP enabled Telephones, PDAs, and personal communication devices.

CPE 693 Advanced Topics in Engineering. (Variable 1 to 4 Hours) Graduate standing in engineering. Lectures on advanced topics of special interest to students in various areas of computer engineering are introduced. This course number is used to offer and test new courses.

CPE 695 Scientific Writing Seminar. (1 Hour) Exercises in scientific writing format and style, with particular emphasis on writing abstracts and manuscripts for publication in referred archival journals.

CPE 696 Seminar. (1 Hour) Presentation of papers, projects and reports by visiting lecturers, graduate students, engineers, and community leaders.

CPE 697 Internship. (Variable 1-3 Hours) Supervised graduate internship or externship in selected areas. Prerequisite: permission of Department.

CPE 698 Independent Study. (Variable 1-4 Hours) Intensive study of a special engineering project including research and literature review selected in accordance with the student's interests and arranged in consultations with the advisor. Topics will vary. Student will make periodic reports as well as a paper at the end of the semester. Prerequisite: permission of Department.

CPE 699 Thesis Research. (Variable 1-6 hrs) Master's thesis representing independent and original research. Prerequisite: permission of advisor.

CPE 899 Dissertation Research. (Variable 1-6 Hours) Dissertation representing independent and original research.

Doctor of Philosophy
COMPUTATIONAL AND DATA-ENABLED SCIENCE AND ENGINEERING (CDS&E)

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Dr. D. Sutton, Associate Professor
Dr. P. Tchounwou, Presidential Distinguished Professor
Dr. C. Yedjou, Associate Professor

CDS&E Ph.D. Program – Overview
The Computational and Data-Enabled Science & Engineering program is an interdisciplinary data-intensive science program in the college of Science, Engineering and Technology at Jackson State University. The new program's paradigm is the interface between large data computational science and the application of biological concepts, mathematical and statistical approaches, engineering methods and public Health practices in science education and research. The program includes the disciplines of Biology, Computer Engineering, Computer Science, Civil and Environmental Engineering, Physical Sciences, Mathematics & Statistical Sciences, and Public Health. The new doctoral program in Computational and Data-Enabled Science and Engineering requires a minimum of 72 credit hours beyond the Bachelor's degree or a minimum of 48 credit hours beyond the Master's degree.

Objectives of the CDS&E Ph.D. Program
The educational objectives of the Ph.D. program in Computational and Data-Enabled Science and Engineering Program are:

1. To provide students with advanced theoretical, analytical, and applied interdisciplinary research training of high quality at the Ph. D. level.
2. To provide the necessary structures, learning opportunities, and experiences beyond the traditional university curriculum required for diversity and interdisciplinary collaborations in areas of Computational Biology and Bioinformatics, Computational Mathematics and Statistical Sciences, Computational Physical Sciences, Computational Science and Engineering and Computational Public Health.
3. To produce highly competent graduates with terminal degrees in Computational and Data-Enabled Science and Engineering disciplines, who will join the workforce in the industry, in academia, and in state and federal agencies, and will assume future leadership roles in computing-centric and Big Data fields.

Specialized Tracks in CDS&E
The following Specialized Tracks are being offered:

- Computational Biology an Bioinformatics
- Computational Mathematics and Statistical Sciences
- Computational Physical Sciences
- Computational Science and Engineering
- Computational Public Health Science

Admission Requirements
To be considered for admission, the following requirements should be met:

1. Applicants must have completed the Graduate Application for Admission.
2. Applicants must have provided official copies of transcripts from all colleges/universities attended.
    a) The applicant must have a Bachelor's or Master's degree from an accredited college or university in STEM and Public Health Sciences, and

b) A minimum GPA of 3.00 (on a 4.00 scale) on the highest degree earned.

3. A satisfactory TOEFL score for international students whose native language is not English.
4. Three letters of recommendation from three professors knowledgeable of the applicant's professional academic ability, job experiences, and leadership potential.
5. A statement of purpose.

The above listed are the minimal requirements, and do not guarantee acceptance into the program.

Degree Requirements

The requirements for the Doctorate of Philosophy Degree in Computational Data-Enabled Science and Engineering are:

- A minimum of 72 credit hours beyond the Bachelor's Degree

or

- A minimum of 48 credit hours beyond the Master's Degree.

For an applicant with a Master's Degree, the course and Dissertation credit hour requirements shall be decided by the Graduate Admissions Committee of the Ph.D. program after evaluating the applicant's transcripts and academic records.

Additional requirements include:

1. Satisfactory performance on the Comprehensive; and
2. Successful defense of the dissertation research. The final basis for granting the degree shall be the candidate's grasp of the subject matter in a specialized track of CDS&E, and a demonstrated ability to express thoughts clearly and forcefully in both written and oral presentations.

Curriculum

Requirements for students with a Bachelor's Degree

Common Core	12 credit hours
Track Requirements	12 credit hours
Track Electives	24 credit hours
Dissertation	24 credit hours
Total	72 credit hours*

**Minimum requirements; additional requirements may be recommended by the Doctoral Committee*

Requirements for students with a Master's Degree

The course and dissertation credit hour requirements will be decided by the Graduate Admissions Committee of the PhD program after evaluating the applicant's transcripts.

Special Requirements

Candidacy

To become a candidate for the Doctorate of Philosophy in Computational and Data Enabled Science and Engineering, the student must have:

1. Completed the formal coursework with a GPA of 3.0 or better.
2. Passed a comprehensive examination. A grade of B or higher will be required for passing. The student will be required to take the comprehensive examination, not sooner than in their second semester, and within the first 2 years of admission into the program. They will be required to pass within 5 semesters of admission, and will have two opportunities for passing.
3. Additionally, the student will need to present and defend an original research proposal to his/her Doctoral Committee. Students will be able to present their research proposal following passing the comprehensive qualifying examination.
4. Filed with the dean of the Graduate School, the dissertation proposal approved by the student's Doctoral Committee, the program director and the academic college dean.

Doctoral Committee

Each student shall have a Doctoral Committee to guide his/her program of study. The committee will consist of at least five graduate faculty members including a major professor and at least three other graduate faculty members from the respective track. Students are encouraged to choose their major professors early in their programs of study. The student and the major professor will then select the other committee members. The departmental Graduate Coordinator will serve as temporary advisor for the student until the major professor is chosen.

Common Core Courses (12 hrs)		**Semester**
Course	**Title**	**Hours**
CSC 552	Applied Programming	3
CSC 601	Computing Algorithms	3
CSC 620	Database Management Systems	3
STAT 672	Computational Statistics	3
or		
STAT 661	Advanced Probability and Statistics	3

Computational Biology and Bioinformatics Track

Required Courses (12 hrs)		**Semester**
Course	**Title**	**Hours**
CSC 651	Foundations of Programming and Computer Systems	3
BIO 509	Genetics	3
BIO 540	Cell Biology	3
BIO 679	Statistics for Bioinformatics	3

Elective Courses (24 hrs)

Elective Courses will be approved by the students graduate committee. A sample list of elective courses for this track is as follows:

Elective Courses		Semester
Course	**Title**	**Hours**
BIO 601	Statistical Genomics	3
BIO 603	Protein Informatics	3
BIO 615	Mathematical Modeling of Biological Systems	3
BIO 619	Computational Proteomics and Genomics	3
BIO 623	Systems Biology and Signaling Networks	3
BIO 635	Cancer Biology	3
BIO 689	Advanced Seminar in Computational Biology	1
BIO 709	Analysis and Visualization of Large Scale Genomic Data Sets	4
BIO 711	Computational Genomics	3
BIO 713	Computational Systems Biology	3
Dissertation (24 hrs)		
BIO 899	Dissertation Research	1-9

Computational Mathematics and Statistical Sciences Track

Required Courses (12 hrs)		Semester
Course	**Title**	**Hours**
MATH 670	Computational Methods in Mathematics I	3
MATH 671	Computational Methods in Mathematics II	3
STAT 661	Advanced Probability and Statistics	3
MATH 673	Quantitative Exploration of Data	3

Elective Courses (24 hrs)

Elective Courses will be approved by the student's graduate committee. A sample list of elective courses for this track are as follows:

Electives Courses		Semester
Course	**Title**	**Hours**
CSC 511	Parallel and Distributed Computing	3
CSC 812	High Performance Scientific Computing	3
MATH 700	Topics in Mathematical and Statistical Applications in CDS&E	3
MATH 543	Numerical Analysis	3
MATH 571	Advanced Numerical Analysis I	3
MATH 572	Advanced Numerical Analysis II	3
MATH 577	Ordinary Differential Equations I	3
MATH 578	Ordinary Differential Equations II	3
MATH 628	Advanced Partial Differential Equations I	3
MATH 629	Advanced Partial Differential Equations II	3
STAT 680	Computational Data Analysis and Visualization I	3
STAT 681	Computational Data Analysis and Visualization II	3
MATH 561	Probability and Statistics I	3
MATH 562	Probability and Statistics II	3
Dissertation (24 hrs)		
MATH 899	Dissertation Research	1-9

Computational Physical Sciences Track

Required Courses (12 hrs)		Semester
Course	**Title**	**Hours**
CSC 651	Foundations of Programming and Computer Systems	3
CHEM 768	Molecular Quantum Mechanics	3
PHY 522	Quantum Theory	3
PHY 533	Solid State Physics	3

Elective Courses (24 hrs)		Semester
Course	**Title**	**Hours**
CHEM 734	Physical Biochemistry	3
CHEM 752	Atomic and Molecular Spectroscopy	3
CHEM 753	Thermodynamics	3
CHEM 754	Kinetics	3
CHEM 758	Quantum Chemistry	3
CHEM 763	Statistical Mechanics	3
CHEM 787	Nanoscience and Nanotechnology	3
PHY 512	Classical Electrodynamics	3
PHY 531	Atomic and Nuclear Physics	3
PHY 561	Computational Methods in Physics	3
PHY 621	Quantum and Nonlinear	3

	Optics	
PHY 640	Relativistic Quantum Field Theory	3
PHY 634	Concepts and Phenomena of Condensed Matter Physics	3

Dissertation Course

PHY 899/CHEM 899	Dissertation Research	1-9

Computational Science and Engineering Track

Required Courses (12 hrs)		**Semester**
Course	**Title**	**Hours**
CSC 511	Parallel and Distributed Computing	3
CSC 571	Programming for Big Data	3
CSC 621	Machine Learning	3
CSC 641	Network Science	3

Elective Courses (24 hrs): Elective Courses will be approved by student's doctoral committee. A sample list of elective courses for this track are as follows:

Elective Courses		**Semester**
Course	**Title**	**Hours**
CSC 537	Cloud Computing	3
CSC 562	Artificial Neural Networks	3
CSC 573	Modeling and Simulation of Complex Systems	3
CSC 582	Social Network Analysis	3
CSC 630	Computability and Complexity	3
CSC 634	Big Data Mining	3
CSC 635	Big Data for Cyber Security	3
CSC 653	Large-Scale Computing	3
CSC 661	Software Engineering for Computational Applications	3
CSC 663	High Performance Scientific Computing	3

Dissertation (24 hrs)

CSC 899	Dissertation Research	1-9

Computational Public Health Science Track

Required Courses (12 hrs)		**Semester**
Course	**Title**	**Hours**
CSC 751	Foundations of Programming and Computer Systems	3
PHS 701	Advanced Biostatistics and Computer Science Applications	3
PHS 707	Public Health Informatics—Under development	3
PHEP 711	Behavioral and Psychosocial Epidemiology	3

Electives (24 hrs): Elective Courses will be approved by the student's graduate committee. A sample list of elective courses for this track are as follows:

Elective Courses		**Semester**
Course	**Title**	**Hours**
PHS 505	Principles of Epidemiology	3
PHS 506	Research and Quantitative Methods	3
PHS 531	Health Behavior Promotion and Education	3
PHS 703	Designing Research Studies for Minorities and Special Populations	3
PHS 705	Advocacy and Public Health Policies	3
PHS 706	Principles of Environmental and Occupational Health	3
ENV 702	Environmental Health	3
ENV 720	Environmental and Occupational Health	3
ENV 717	Introduction to Remote Sensing for Environmental Science	3
ENV 718	Application of Remote Sensing in Environmental Science	3
ENV 751	Water Quality Management	3
ENV 755	Air Quality Management	3
ENV 800	Environmental Toxicology	3
ENV 801	Risk Assessment and Management	3

Dissertation (24 hrs)

CPHS 899	Dissertation Research	1-9

DESCRIPTION OF COURSES

Common Core Courses

CSC 552 Applied Programming (3 Hours): Prerequisite: Department and advisor approval. This course focuses on the fundamentals of computing and is geared toward non-CS majors going into computational sciences. The course will cover key concepts of data structures, data manipulation, algorithms and efficiency, and how they apply to the various application domains specific to computational fields. The course will also provide an introduction to Python for computational sciences. Topics include: an introduction to computational complexity, data structures (arrays, lists, stacks, queues, trees, and

graphs), elementary algorithms and their complexity.

CSC 601 Computing Algorithms (3 Hours): Prerequisite: CSC 515 Data Structures and Algorithm Analysis or department approval. The course focuses on algorithms of different design strategies, and the mathematical concepts used in describing the complexity of an algorithm. Topics covered include: Asymptotic notations; Time complexity analysis of iterative and recursive algorithms; Classical design strategies like Exhaustive search, Brute force, Divide and Conquer, and Greedy; Advanced design strategies like Dynamic Programming, Branch and Bound, Randomized algorithms; Space-time tradeoffs in algorithms and NP-completeness - Heuristics and Approximation algorithms. The course will also cover graph theory algorithms with respect to the application of the above design strategies for specific problems.

CSC 620 Database Management Systems (3 Hours): This course is designed for non-computer science majors entering the Ph.D. in Computational and Data Enabled Sciences and Engineering. It introduces students to the concepts and theories of database systems, necessary in the CDS&E fields. Topics include: information models and systems; the database environment; data modeling; conceptual modeling using the entity-relationship approach and mapping to relational tables; the relational model including the relational data structure, integrity rules, relational algebra and relational calculus; normalization; data definition and data manipulation in SQL; conceptual, logical, and physical database design; security; transaction management; query processing; and advanced topics in database systems, and how this applies to computational and data enabled sciences and engineering.

STAT 661 Advanced Probability and Statistics (3 Hours): Prerequisite: Mathematics 532 or approval of department. Basic concepts of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, and decision functions.

Computational Biology and Bioinformatics Track

Required Courses

CSC 651 Foundations of Programming and Computer Systems (3 Hours): This course will focus on graduate-level central concepts in modern programming languages, impact on software development, language design trade-offs, and implementation considerations. Functional, imperative, and object-oriented paradigms. Formal semantic methods and program analysis. Modern type systems, higher order functions and closures, exceptions and continuations. Modularity, object-oriented languages, and concurrency. Runtime support for language features, interoperability, and security issues. Prerequisite: experience in any object-oriented language.

BIO 509 Genetics (3 Hours): This course discusses the principles of genetics with application to the study of biological function at the level of cells and multi-cellular organisms, including humans. The topics include: structure and function of genes, chromosomes and genomes, biological variation resulting from recombination, mutation, and selection, population genetics, use of genetic methods to analyze protein function, gene regulation and inherited disease.

BIO 540 Cell Biology (3 Hours): The course will provide an in-depth knowledge regarding the chemistry of the cell, the macromolecules of the cell, bioenergetics that regulate the flow of energy in the cell and the enzymes that catalyze the biochemical processes in the cell. The cell function and its regulation will be emphasized in this course through elaborate discussions of signal transduction mechanisms and gene expression and the pathways that regulate gene expression, including messengers and receptors, extracellular structures and cell adhesion molecules, DNA replication, protein synthesis and sorting. New developments in gene expression biotechnology and recombinant DNA, in addition to proteomics will be discussed.

BIO 679 Statistics for Bioinformatics (3 Hours): This course aims to introduce concepts of bioinformatics such as DNA pattern finding, gene expression data analysis, molecular evolution models, and bio-molecular sequence database searching. Introduction of the necessary probability and statistics: events, (conditional) probability, random variables, estimation, testing, and linear and multiple regression analyses are covered in this course.

Elective Courses

BIO 601 Statistical Genomics (3 Hours): A course in algorithms and knowledge of at least one computing language (e.g., R, matlab) is recommended. Statistical Genomics is one of the fundamental areas of research in the biological sciences and is rapidly becoming one of the most important application areas in statistics. This course provides an introduction to statistical and computational methods for the analysis of meiosis, population genetics, and genetic mapping. Applications focus on sequence analysis, and high-throughput microarray and sequencing gene expression.

BIO 603 Protein Informatics (3 Hours): This course will introduce students to the fundamentals of molecular biology, and to the bioinformatics tools and databases used for the prediction of protein function and structure. It is designed to establish a theoretical understanding of computational methods, as well as experience with protein sequence analysis methods and application to real data.

BIO 607 Physical Biology (3 Hours): The course provides theory and application of cascade models predicting the behavior of the individual molecules participating in a cascade and the kinetics of the biochemical reactions that may govern cascades of cellular and molecular transduction of signaling networks. Chemical reaction cycles, including temporal and structural dynamics of the signaling cascade needs are evaluated. validation of the theoretical insights in a specific biological signal transduction model that

incorporates the realistic molecules and biochemical reactions will be discussed and applied.

BIO 613 Computational Systems Biology and Epigenetics (3 Hours): In systems biology, epigenetic switches have received increased attention. Multiple phenotypes are usually represented as multiple stable attractors in deterministic descriptions of the biochemical dynamics from the response of lac operon to the synthetic genetic networks. Theory and application of mathematical analysis in epigenetics will be discussed to understand the multiple phenotypes usually represented as multiple stable attractors in deterministic descriptions of the biochemical dynamics. The system biology model provides a mechanism of positive or negative feedback in modulating the epigenetic switches. In this course, mathematical models of stepwise heterochromatin silencing will be introduced and discussed. Epigenetic states can be explained as a consequence of the existence of two stable uniform static solutions: the hyper-acetylated state and silenced states on DNA.

BIO 615 Mathematical Modeling of Biological Systems (3 Hours): Mathematical and computational models are increasingly used to help interpret biomedical data produced by high-throughput genomics and proteomics projects. The application of advanced computer models enabling the simulation of complex biological processes generates hypotheses and suggests experiments. Appropriately interfaced with biomedical databases, models are necessary for rapid access to, and sharing of knowledge through data mining and knowledge discovery approaches.

BIO 619 Advanced Genetics (3 Hours): The course focuses on casting contemporary problems in systems biology and functional genomics in computational terms and providing appropriate tools and methods to solve them. Topics include genome structure and function, transcriptional regulation, and stem cell biology, measurement technologies such as microarrays (expression, protein-DNA interactions, chromatin structure), statistical data analysis, predictive and causal inference, and experiment design. The emphasis is on coupling biological structures with appropriate computational approaches.

BIO 623 Systems Biology and Signaling Networks (3 Hours): This course will focus on the application of the principles of systems biology and signaling network biology and how information flow approaches can be applied to solve various biological problems, including uncovering causal genes and pathways, identifying disease genes, predicting gene functions, and network centrality.

BIO 635 Cancer Biology (3 Hours): Understanding the molecular and cellular events involved in tumor formation, progression, and metastasis is crucial to the development of innovative therapy for cancer patients. Insights into these processes have been advanced through basic research using biochemical, molecular, and genetic analysis. This course will explore the laboratory tools and techniques used to perform cancer research, major discoveries in cancer biology, and the translational implications of these breakthroughs. A focus of the class will be critical analysis of the primary literature to foster understanding of the strengths and limitations of various approaches to cancer research. Special attention will be made to the clinical implications of cancer research performed in model organisms.

BIO 689 Advanced Topics in Computational Biology (1 Hour): Papers covered are selected to illustrate important problems and approaches in the field of computational and systems biology, and provide students a framework from which to evaluate new developments. Computational and Systems Biology links biology, engineering, and computer science in a multidisciplinary approach to the systematic analysis and modeling of complex biological phenomena. This course is one of a series of core subjects offered for students with an interest in interdisciplinary training and research in the area of computational and systems biology.

BIO 709 Analysis & Visualization of Large Scale Genomic Data Sets (4 Hours): The goal of this course is to introduce students to computational issues involved in analysis and display of large-scale biological data sets. Techniques covered will include clustering and machine learning techniques for gene expression microarrays and proteomics data analysis, biological networks and pathways modeling, data integration in genomics, and visualization issues for large-scale data sets. An introduction to the field of bioinformatics and the nature of biological data will be provided. In depth knowledge of computer science is not required, but students must have some understanding of computation. The course will be taught in a mixed lectures and seminar format, and will involve completing a project and a final exam.

BIO 711 Computational Genomics (3 Hours): This course introduces the mathematical modeling techniques needed to address key questions in modern biology. An overview of modeling techniques in molecular biology and genetics, cell biology and developmental biology is covered. Key experiments that validate mathematical models are also discussed, as well as molecular, cellular, and developmental systems biology, control theory and genetic networks, and gradient sensing systems. Additional specific topics include: constructing and modeling of genetic networks, synthetic genetic switches, circadian rhythms, reaction diffusion equations, local activation and global inhibition models, center finding networks, general pattern formation models, and modeling cell-cell communication.

Dissertation Course

BIO 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Biology. Prerequisite: permission of advisor.

Computational Mathematics and Statistical Sciences Track

Required Courses

MATH 670 Computational Methods in Mathematics I (3 Hours): This course is designed to give an overview of the design, analysis and implementation of the most fundamental numerical techniques in numerical linear algebra, the interpolation of functions, and the evaluation of integrals. This course in most part will depend on programming with MATLAB and/ or C++. While we present many MATLAB examples throughout the course, students are strongly advised to have some previous programming experience in any computer programming language.

MATH 671 Computational Methods in Mathematics II (3 Hours): This course is a continuation of MATH 770. Topics covered includes introduction to mathematical and computational problems arising in the context of molecular biology. Theory and applications of combinatorics, probability, statistics, geometry, and topology to problems ranging from sequence determination to structure analysis. The course depends on parallel and distributed programming.

STAT 661 Advanced Probability and Statistics (3 Hours): Prerequisite: Mathematics 532 or approval of department. Basic concepts of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, and decision functions.

STAT 672 Computational Statistics (3 Hours): Prerequisite: Departmental approval. This course teaches students to use R, SAS, SPSS and write programs for basic data analysis, simple and multiple regressions, factor analysis, principal component analysis, model selection, variance analysis as well as modeling data and implementations of simulation through random number generating, Monte Carlo method and bootstrapping.

MATH 673 Quantitative Exploration of Data (3 Hours): This course covers how to analyze and mine data with the Structured Query Language (SQL). Understand SQL fundamentals, and then advance into the uses of SQL data analysis and data mining with real applications. Learn to use Microsoft Excel to further analyze, manipulate and present your data exploration and data-mining findings in tabular and graphical formats. Students will be exposed to Extreme Science and Engineering Discovery Environment (XSEDE).

Elective Courses

CSC 511/CSC 611 Parallel and Distributed Computing (3 Hours): Prerequisite: CSC 512 Computer Architecture or approval of Department. The course introduces the concepts and design of parallel and distributed computing systems. Topics covered include: Data versus control parallelism (SIMD/Vector, Pipelines, MIMD, Multi-core, GPU); Shared versus distributed memory (SMP and NUMA), Message passing Interface (MPI) and Topologies; Parallel and distributed algorithms: Paradigms, Models and Complexity, Scheduling, Synchronization, Deadlock detection, Fault tolerance and Load balancing.

MATH 543 Numerical Analysis (3 Hours): This course covers elements of error analysis, real roots of an equation, polynomial approximation by finite difference and least square methods, interpolation, quadrature, numerical solution of ordinary differential equations, and numerical solutions of systems of linear equations. Students are expected to use MATLAB and other program languages to solve problems numerically.

MATH 561-562 Probability and Statistics I-II. (3-3 Hours): Prerequisite: Mathematics 532 or approval of department. Basic concepts of measure theory and integration axiomatic foundations of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, decision functions.

MATH 571 Advanced Numerical Analysis I (3 Hours): This course is an introduction to parallel computer programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations.

MATH 572 Numerical Analysis II (3 Hours): This course is a continuation of MATH 625. Topics covered include, iterative solution of systems of nonlinear equations, evaluation of eigenvalues and eigenvectors of matrices, applications to simple partial differential equations and quantitative exploration of data.

MATH 577-578 Ordinary Differential Equation I--II. (3-3 Hours): Ordinary differential equations: basic theorems of existence, uniqueness, and continuous dependence of the solutions; linear differential equations and systems; stability theory; topology of integral curves; differential equations in the complex domain, asymptotic integration; boundary value problems. Partial differential equations; equations of first order method of characteristics, Hamilton-Jacobi theory; equations of second order-classification according to type; elliptic equations-potential equation, maximum principle, characteristics, and other topics of interest.

MATH 628 Advanced Partial Differential Equations I (3 Hours): The theory of initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations, with emphasis on nonlinear equations. Laplace's equation, heat equation, wave equation, nonlinear first-order equations, conservation laws, Hamilton-Jacobi equations, Fourier transform, Sobolef and other spaces, etc.

MATH 629 Advanced Partial Differential Equations II (3 Hours): The theory of boundary value and initial value problems for partial differential equations, with emphasis on nonlinear equations. Second-order elliptic equations, parabolic and hyperbolic equations, calculus of variations methods, additional topics selected by instructor.

CSC 663 High Performance Scientific Computing (3 Hours): The course will focus on design of high performance parallel programs for scientific computing. Topics covered include: Single-processor performance, memory hierarchy and pipelines; parallel system organization; message passing and MPI

programming; Problem decomposition, graph partitioning, load balancing, Shared memory, CUDA, GPU and Open MP programming.

STAT 680 Computational Data Analysis and Visualization I (3 Hours): This course is about learning the fundamental computing skills necessary for effective data analysis.

STAT 681 Computational Data Analysis and Visualization II (3 Hours): This course covers exploratory and objective data analysis methods applied to the physical, engineering, and biological sciences.

MATH 700 Mathematical and Statistical applications (3 Hours): The course may be repeated for credit. It covers current trends and challenges of mathematical and statistical applications in CDS&E.

MATH 827 Numerical Solution of Differential Equations (3 Hours): Ordinary differential equations: Runge-Kutta and predictor-corrector methods; stability theory, Richardson extrapolation, stiff equations, boundary value problems. Partial differential equations: stability, accuracy and convergence, Von Neumann and CFL conditions, finite difference solutions of hyperbolic and parabolic equations. Finite differences and finite element solution of elliptic equations.

Dissertation Course

MATH 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Mathematics and Statistical Sciences. Prerequisite: permission of advisor.

Computational Physical Sciences Track

Required Courses

CSC 651 Foundations of Programming and Computer Systems (3 Hours): This course is designed to give students breadth-wise knowledge and foundation in critical aspects of programming and computer systems. The programming concepts to be covered include those for procedural and object-oriented programming using appropriate high-level languages. The computer systems concepts will be covered with regards to Computer Architecture, Operating Systems and Networking. In addition, the course will introduce a broad range of problem-solving skills that can aid scientists to develop software for their field of interest.

CHEM 768 Molecular Quantum Mechanics (3 Hours): Theoretical, algorithmic, and practical aspects of the methods of molecular quantum mechanics and their applications to chemical systems. Topics covered include Hartree-Fock theory, perturbation theory, configuration interaction, coupled-cluster theory, and density-functional theory.

PHY 522 Quantum Theory (3 Hours): This course covers basic concepts and methods of quantum theory. Topics include mathematical apparatus of quantum mechanics, basic concepts of quantum mechanics, Schrodinger equation, reflection and transmission of plane waves for various potential steps and dips, harmonic oscillator in quantum mechanics, quantum theory of one-electron atom, perturbation theory, scattering theory.

PHY 533 Solid State Physics (3 Hours): This course covers basic concepts and methods of solid state theory. Topics include crystal structure and symmetry, diffraction of x-rays by crystals, acoustic and optical phonons, electron motion in a periodic potential, energy bands, nearly free electron model and tight-binding model, classification of solid states, introduction to phase transitions and collective phenomena.

Elective Courses

CHEM 734 Physical Biochemistry (3 Hours): Characterization of macromolecules, hydrodynamic methods, multiple equilibria, maromolecule-ligand interactions.

CHEM 752 Atomic and Molecular Spectroscopy (3 Hours): A comprehensive course covering concepts and methods of modern atomic and molecular spectroscopy. Subjects covered include electric phenomena, absorption and emission of radiation, atomic spectroscopy, rotational spectroscopy, vibrational spectroscopy, electronic spectroscopy, and magnetic resonance spectroscopy.

CHEM 753 Thermodynamics (3 Hours): Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

CHEM 754 Kinetics (3 Hours): Mechanics of chemical reactions, cross sections, and rate constants. Elastic, inelastic, and rearrangement channels using quantum and semi-classical techniques.

CHEM 758 Quantum Chemistry (3 Hours): Important concepts of quantum chemistry at the intermediate level, including angular momentum, perturbation theory, electronic structure of molecules, and radiation matter interaction. Applications will vary from year to year.

CHEM 763 Statistical Mechanics (3 Hours): A study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions, and cluster theory.

CHEM 787 Nanoscience and Nanotechnology (3 Hours): A comprehensive course provides an overview to the rapidly developing field of nanoscience and nanotechnology with special emphasis on general and material chemistry, environmental science, biotechnology and modeling. The topics include properties of individual nanoparticles, bulk nanostructures, carbon nanotubes, quantum wells, wires and dots; the tools and methods for measuring these properties; methods for growing and synthesizing nanomaterials; applications in biological materials and the fabrication of nanomachines and devices.

PHY 512 Classical Electrodynamics (3 Hours): This course covers main concepts and methods of classical electrodynamics. Topics include electrostatics, magneto-statics, electric and magnetic fields in matter,

Maxwell's equations, potentials and fields for moving charges, electromagnetic waves, and special relativity.

PHY 531 Atomic and Nuclear Physics (3 Hours): Prerequisite: PHY 422 or approval of department. This course covers (atomic physics) the structure of hydrogen atom, alkali atoms, the excitation of atoms, electric dipole selection rules, atoms in magnetic field, normal Zeeman effect, coupling of orbital and spin angular moments, general Pauli principle and electron anti-symmetry, hyper-fine-structure, (nuclear physics) properties of nuclei (Rutherford scattering, size, mass and binding energy), nuclear forces, nuclear shell model, nuclear collective model, alpha and beta decay, and fusion and fission.

PHY 561 Computational Methods in Physics (3 Hours): In this course, students will study how to: get approximate solutions of linear and certain nonlinear equations with some numerical algorithms in physics, such as large angular motion of a pendulum; formulate numerical algorithms for the solution of common second order linear partial differential equations in physics, such as Laplace equation, Poisson equation, Fourier equation of heat flow; and write computer programs to implement the formulated numerical algorithms and output the calculated
values of selected physical quantities.

PHY 621 Quantum and Nonlinear Optics (3 Hours): Prerequisites: PHY 512, PHY 522 or permission of the department. Introduction to main concepts and methods of nonlinear optics. Topics include anharmonic classical electron oscillator, nonlinear optical tensors and their symmetry properties, macroscopic time-domain response, electrodynamics of nonlinear optics, higher-order nonlinear response, nonlinear phenomena in optical fibers.

PHY 634 Concepts and Phenomena of Condensed Matter Physics (3 Hours): This course covers basic concepts and methods of condensed matter physics. Topics include elementary excitations in condensed matter, electrons in metals, phonons and electron-phonon interactions, density-functional theory, superconductivity, and mesoscopic systems.

PHY 640 Relativistic Quantum Field Theory (3 Hours): This course covers quantization of scalar, vector and fermion fields, Yukawa theory, QED, regularization and renormalization, the renormalization group, fermion path integrals, non-abelian gauge theory, symmetry breaking and some aspects of the Standard Model. Computer computation of Feynman amplitudes and other big data computational packages will be also discussed.

Dissertation Course

PHY 899/CHEM 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Physical Sciences. Prerequisite: permission of advisor.

Computational Science and Engineering Track

Required Courses

CSC 551 Parallel and Distributed Computing (3 Hours): Prerequisite: CSC 512 Computer Architecture or approval of Department. The course introduces the concepts and design of parallel and distributed computing systems. Topics covered include: Data versus control parallelism (SIMD/Vector, Pipelines, MIMD, Multi-core, GPU); Shared versus distributed memory (SMP and NUMA), Message passing Interface (MPI) and Topologies; Parallel and distributed algorithms: Paradigms, Models and Complexity, Scheduling, Synchronization, Deadlock detection, Fault tolerance and Load balancing.

CSC 571 Programming for Big Data (3 Hours): The course will expose students to three programming paradigms for big data analytics to cover the three Vs: Velocity, Volume, and Variety. The course will focus on design and development of programs based on the: (1) Supervised and unsupervised machine learning algorithms to perform predictive analytics of Big Data and implement them using a high-level interpreted language such as Octave; (2) Map-reduce parallel programming paradigm for selected data-intensive computational problems; (3) Functional programming paradigm using languages such as OCaml to analyze big data in a recursive fashion. In addition, the course will enable students to be able to configure a distributed file system based on the Hadoop architecture for reliable shared storage and develop programs that interface with it, as well as manage large datasets using SQL-like access to unstructured data (Hive) and NoSQL storage solutions (HBase).

CSC 621 Machine Learning (3 Hours): Pre-requisite: CSC 601 Computing Algorithms or CSC 515 Data Structures and Algorithm Analysis or CSC 323 Algorithm Design and Analysis. This course will deal enable students to understand the underlying algorithms used in various learning systems. Topics covered include: Inductive classification, Decision-tree learning, Ensembles, Experimental evaluation, Computational learning theory, Rule learning, Neural network learning, Support vector machines, Bayesian learning, Instance-based learning and Text categorization.

CSC 641 Network Science (3 Hours): Pre-requisite: CSC 601 Computing Algorithms or CSC 515 Data Structures and Algorithm Analysis or CSC 323 Algorithm Design and Analysis. Topics covered include the measurement and structure of networks, methods for analyzing network data, including methods developed in physics, statistics, and sociology, graph theory, computer algorithms, mathematical models of networks, including random graph models and generative models, and theories of dynamical processes taking place on networks.

Elective Courses

CSC 537 Cloud Computing (3 Hours): The course will present the state of the art in cloud computing

technologies and applications as well as providing hands-on project opportunities and experiment with different technologies. Topics will include: telecommunications needs; architectural models for cloud computing; cloud computing platforms and services; security, privacy, and trust management; resource allocation and quality of service; cloud economics and business models; pricing and risk management; interoperability and internetworking; legal issues; and novel applications.

CSC 562 Artificial Neural Networks (3 Hours): This course will focus on graduate-level topics in artificial neural networks, including: Rosenblatt's perceptron, model building through regression, the least-mean-square algorithm, multilayer perceptrons, kernel methods and radial-basis function networks, support vector machines, regularization theory, principal-components analysis, self-organizing maps, information-theoretic learning models, stochastic methods rooted in statistical mechanics, neurodynamics, and dynamically driven recurrent networks.

CSC 573 Modeling and Simulation of Complex Systems (3 Hours): The course focuses on the application of modeling and simulation principles to large-scale non-linear complex systems with interconnected parts (like a biological cell, economy or an ecological system). Topics covered include: non-linear differential equations, networks, stochastic models, cellular automata, agent-based modeling and swarm-like systems.

CSC 582 Social Network Analysis (3 Hours): This course will cover the structure and analysis of large social networks on models and algorithms that abstract their properties. Topics covered include: Nodes, edges, and network measures, structure, and visualization and tools, the tie strength of networks, trust in social media, analyzing and classifying user roles, attributes and behavior, link prediction and entity resolution, epidemic models, location-based social media analysis, social sharing and filtering, aggregation and data mining, and network strategies for the individual and for the government.

CSC 630 Computability and Complexity (3 Hours): This course will cover advanced topics in computability and complexity theory. Computability topics covered include: Church-Turing Thesis, Decidability, Reducibility, Recursion Theorem and Decidability of logical theories. Complexity topics covered include: Time Complexity (P, NP, NP-Completeness), Space Complexity (Savitch's theorem, PSPACE, NL-Completeness), Intractability, Probabilistic algorithms and Alternation.

CSC 634 Big Data Mining (3 Hours): Pre-requisite: CSC 621 Machine Learning or department approval. This course will focus on data mining of very large amounts of data that is so large enough not to fit in main memory, characteristic of data retrieved from the web. Topics to be covered include: Distributed file systems and Map Reduce, Similarity search techniques, Real-time data-stream processing algorithms, Technology of search engines (PageRank, Link-spam detection, hubs-and-authorities approach) and Frequent-item set mining. The course will also expose students to algorithms for clustering very large, high-dimensional datasets.

CSC 635 Big Data for Cyber Security (3 Hours): Pre-requisite: CSC 621 Machine Learning or department approval. This course will focus on data-driven approaches to detect threats and attacks that originate from diverse channels at a rapid rate, necessitating the need for scalable distributed monitoring and cross-relation with a substantial amount of contextual information. The course will cover various anomaly-based Big Data analytics solutions for Cyber Security.

CSC 653 Large-Scale Computing (3 Hours): Prerequisite: CSC 551 Parallel and Distributed Computing. The course will focus on large-scale modeling techniques, algorithms and computational techniques for Big Data computing. Large-scale modeling techniques covered will include linear models, graphical models, matrix and tensor factorizations, clustering, and latent factor models. Algorithmic topics include sketching, fast n-body problems, random projections and hashing, large-scale online learning, and parallel learning. The computational techniques covered in this course will provide a basic foundation in large-scale programming, ranging from the basic "parfor" to parallel abstractions, such as MapReduce (Hadoop) and GraphLab.

CSC 661 Software Engineering for Computational Applications (3 Hours): This course focuses on computational software engineering for engineering and scientific applications. Topics include Characteristics of computational software, Development and maintenance activities, Requirement engineering for computational software, Problem analysis and solution design tools, Component reuse, Software reliability, and Computational software validation and verification.

CSC 663 High Performance Scientific Computing (3 Hours): The course will focus on design of high performance parallel programs for scientific computing. Topics covered include: Single-processor performance, memory hierarchy and pipelines; parallel system organization; message passing and MPI programming; Problem decomposition, graph partitioning, load balancing, Shared memory, CUDA, GPU and OpenMP programming.

Dissertation Course

CSC 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Science and Engineering. Prerequisite: permission of advisor.

Computational Public Health Science Track

Required Courses

CSC 751 Foundations of Programming and Computer Systems (3 Hours) This course is designed to give students breadth-wise knowledge and foundation in critical aspects of programming and

computer systems. The programming concepts to be covered include those for procedural and object-oriented programming using appropriate high-level languages. The computer systems concepts will be covered with regards to Computer Architecture, Operating Systems and Networking. In addition, the course will introduce a broad range of problem-solving skills that can aid scientists to develop software for their field of interest.

PHS 701 Advanced Biostatistics and Computer Science Applications (3 Hours) This is an advanced course in biostatistics with emphasis on statistical inference, sample size calculations, and multiple regression techniques. The course emphasizes the use of computer software packages in conducting statistical procedures. The software packages include SPSS, SAS, Epi Info, GIS, and others. Emphasis is placed on selecting the appropriate statistical test and the most appropriate analytical procedure.

PHEP 711 Behavioral and Psychosocial Epidemiology (3 Hours) This course provides an overview of social, personality, and cultural factors influencing behavior. It also addresses stress and related psychosocial factors as determinants of health and disease. Psychosocial and behavior models are discussed. Doctoral students will be required to analyze a specific data set and prepare a research literature report on a specific topic in behavioral and psychosocial epidemiology. A prerequisite for the master's students is PHS 505 Principles of Epidemiology. Prerequisites for doctoral students include PHS 505.

PHS 707 Public Health Informatics (3 Hours) This course introduces an overview and principles of public health informatics. The major contents include how information and computer sciences, including databases, networks, information systems, technologies and computer applications, can be applied to enhance public health practice, research and education. It introduces the entire process, from systems conceptualization and design, to project planning and development, to system implementation and use. The course also covers the issues about management, privacy and confidentiality in development and utilization of information systems. Students will gain hands-on experience in exploring some key public health informatics applications or public health information systems currently served as major sources of data and information.

Elective Courses

PHS 505 Principles of Epidemiology (3 Hours) This course explores the science and practice of epidemiology and its contributions to disease detection, measurement, and prevention in clinical and public health settings. Specific topics include measurement of disease frequency, measurement of disease association, standardization, bias, and study designs. This course also introduces the practical fields of epidemiology.

PHS 506 Research and Quantitative Methods (3 Hours) This course introduces students to applied research methods in public health. It emphasizes essential concepts, techniques and methods of research practice. Basic measurement procedures for analyzing health data are examined through SPSS computer software, and the student is required to complete the design of a research study. Prerequisites: PHS 505.

PHS 531 Health Behavior, Promotion and Education (3 Hours) This course provides a comprehensive understanding of health promotion and health education, concepts and applications. It offers students an opportunity to develop a broad understanding of social, cultural and psychological factors as they affect health and health-related behaviors and outcomes at individual, family, and group/community levels. Areas of responsibilities for health educators, as required by the National Commission for Health Education Credentialing (NCHEC) body, are discussed, and students gain competencies essential to pass the Certified Health Education Specialist (CHES) examination. The CHES related skills and competencies in combination with an MPH degree create better job opportunities at state and national levels.

PHS 703 Designing Research Studies for Minorities and Special Populations (3 Hours) This course examines unique health problems and concerns among African Americans, rural populations, women, children, other minorities and special populations. It describes basic study designs and their strengths and limitations, and addresses specific cultural competencies, research codes of ethics, and health disparities. It also addresses strategies for designing studies and interventions involving lay community leaders, faith-based organizations, and innovative means to reach special communities.

PHS 705 Advocacy and Public Health Policies (3 Hours) This course introduces advocacy and support measures for the promotion and formation of new legislation and the establishment of public health policies. Important federal, state, and international legislation is analyzed. The course also addresses the trends and processes by which public health programs are established in the United States and around the world.

PHS 706 Principles of Environmental and Occupational Health (3 Hours) This course addresses comprehensive public health functions of environmental health issues, evaluation and control of occupational disease hazards, effects of pollutants on human health and ecological balances; and future legislative directions for environmental policy. Topics addressed include environmental health exposures science, environmental health policy (aspects of justice, social, economic, and ethical issues), chemical and physical agents through air, food, water and workplace environment, and behavioral modifications to prevent exposures and promote public health.

ENV 702 Environmental Health (3 Hours) This course focuses on the impact of environmental problems on human health. Health issues related to water pollution/contamination by physical, chemical and biological agents; wastewater discharges;

radiations; air pollution; municipal, and industrial wastes; food contamination; pesticides; occupational hazards; and vector-borne diseases are discussed.

ENV 717 Introduction to Remote Sensing for Environmental Science (3 Hours). This course introduces the theory and techniques of remote sensing and their application to environmental analysis. Topics include the concepts of remote sensing; characteristics of spectro-magnetic waves; types of remotely sensed data; sensor types; the theory of photogrammetric techniques; digital image analysis for acquisition of geographical information. Several lab activities involve: learning of basics of ERDAS Imagine; data acquisition through Internet search for satellite images; importing datasets, band characteristics and visual presentation.

ENV 718 Application of Remote Sensing in Environmental Science (3 Hours). Prerequisite: ENV 717. This course covers the quantitative and applied aspects and analysis of remotely sensed digital data. It is designed to provide an understanding of digital image processing, analysis, and interpretation techniques. Topics include digital data visualization; geometric, radiometric, and atmospheric correction; image enhancement and manipulation; information extraction; digital change detection; integration of GIS and remotely sensed data, and spatial modeling. Laboratory exercises are in-depth applications of the exercise topics that have been covered in ENV 717, as well as thematic information extraction and change detection.

ENV 720 Environmental and Occupational Health (3 Hours). This course explores the relationship and impact of the environment to health and illness in human populations. An exploration of man-made and natural environmental hazards will be discussed. Environmental health and risk assessment will be discussed as well as interventions. Environmental policy and practices will be viewed from the public health perspective and include the study of energy, waste, environmental justice, and regulation.

ENV 751 Water Quality Management (3 Hours). This course provides students with basic concepts and principles in Water Quality Management. The effects of organic, inorganic, biological and thermal pollutants/contaminants in various systems of the hydrologic cycle including streams, reservoirs, and estuaries; eutrophication; water quality criteria and standards; monitoring concepts; methods in water quality management; regulatory considerations; and non point source pollution control, are discussed.

ENV 755 Air Quality Management (3 Hours). This course provides students with basic concepts and principles of air quality management. Contaminant classification, pollutant sources, criteria pollutants, health effects, exposure and risk assessment are discussed. Pollutant measurements and air quality assessment techniques are considered with regard to atmospheric effects on dispersion and transport. Identification of, and control strategies for, stationary and mobile sources, and environmental regulations are studied, and indoor air quality considered.

ENV 800 Environmental Toxicology (3 Hours). Prerequisites: ENV 702. This course is designed to provide an overview of the basic principles and concepts of toxicology including: exposure characterization, dose-response relationship, kinetics and distribution of toxicants in a biological system; to understand the fate, behavior and toxicities of xenobiotic chemicals, and the mechanisms by which they affect cells and organs; and to identify the sources and discuss the effects of various groups of environmental toxicants including heavy metals, pesticides and other industrial byproducts.

ENV 801 Risk Assessment and Management (3 Hours). Prerequisites: ENV 800. This course is designed to provide students with qualitative and quantitative skills necessary to evaluate the probability of injury, disease and death in humans and other life forms, from exposure to various environmental contaminants. Hazard identification, exposure assessment, dose-response evaluation and risk characterization are emphasized. Regulatory and technical aspects of risk assessment in the promulgation of public and environmental safety standards are discussed.

Dissertation Course

CPHS 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Public Health Science. Prerequisite: permission of advisor.