COLLEGE OF SCIENCES
AND ENGINEERING
COLLEGE OF SCIENCES AND ENGINEERING

DIVISION OF COMPUTER SCIENCE

Master of Science Degree in Computer Science

The Master of Science degree program in Computer Science offers integrated studies involving software and hardware leading to the M.S. degree. A thesis option is available for those students who desire to have research experience.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, a B.A. or B.S. in Computer Science equivalent to that offered by UTSA is required as preparation. Those students who do not qualify for unconditional admission may be admitted on a conditional basis. Students who are admitted on a conditional basis may be required to complete specific undergraduate courses as conditions of admission. If such courses are listed as deficiencies, they will not count toward the graduate degree. In such cases, students should anticipate that additional time will be required to complete the degree. All applicants are required to submit scores from the Graduate Record Examination aptitude test (GRE).

Degree Requirements. Candidates for this degree are required to successfully complete 36 semester credit hours of graduate coursework, subject to the following conditions:

A. Required courses (15 hours):

The following three courses (9 hours) are required of all students:
- CS 5513 Computer Architecture
- CS 5523 Operating Systems
- CS 5633 Analysis of Algorithms

Each student must also take at least two courses (6 hours) from the following list:
- CS 5103 Software Engineering
- CS 5233 Artificial Intelligence
- CS 5353 Formal Languages, Automata, and Theory of Computation
- CS 5363 Structure of Programming Languages and Compilers
- CS 5443 Data Base Management

B. Each student must complete at least 15 semester credit hours of additional eligible graduate courses, 9 hours of which must be within the Division of Computer Science. With prior approval of the Graduate Advisor of Record, a student may apply a maximum of 6 hours of graduate courses from other disciplines to the M.S. degree.

C. Each student is required either to write a master's thesis and enroll in 6 semester credit hours of CS 6983 or complete 6 hours of additional graduate coursework in the Division of Computer Science.

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Each candidate must either successfully defend his or her thesis research results in an oral defense or give a public lecture followed by an oral examination on a topic approved by the Graduate Studies Committee.

Doctor of Philosophy Degree in Computer Science

The Division of Computer Science offers advanced coursework and research leading to the Doctor of Philosophy degree in Computer Science. The program emphasizes high-performance computing. Successful Ph.D. candidates must demonstrate an in-depth knowledge of computer science and must deliver an original contribution to the field.

The regulations for this degree comply with the general University regulations (refer to chapters 5, General Academic Regulations, and 7, Doctoral Degree Regulations).

Admission Requirements. The minimum requirements for admission to the doctoral degree program in computer science are as follows:

1. a B.A., B.S., or M.S. degree in computer science or related area
2. a cumulative GPA of 3.30 or higher in the last 60 hours of coursework
3. acceptable scores on the GRE General Test and Computer Science Subject Exam
4. an acceptable TOEFL score for those applicants whose native language is not English
5. three letters of recommendation attesting to the applicant’s readiness for doctoral study.

Admission is competitive. Satisfying the minimum requirements does not guarantee admission. An application should also include a resumé and a statement of research experience and interest.

All students who apply will automatically be considered for one of a small number of doctoral student stipends. The stipend is currently $12,000 for twelve months, with tuition and fees paid. Some teaching and research assistantships are also available.

Course Requirements. The course requirements for the doctoral degree program in computer science are as follows:

A. Core Courses (18 semester credit hours):

   CS 5513   Computer Architecture
   CS 5523   Operating Systems
   CS 5633   Analysis of Algorithms
   CS 6553   Performance Evaluation
   CS 6643   Parallel Processing
   CS 6653   Parallel Algorithms

B. Designated Electives (12 semester credit hours in a single focus):

   1. High-Performance Programming Environments Focus:
The following two courses:
CS 5113 Computer Graphics
CS 5363 Structure of Programming Languages and Compilers

Plus two courses from the following:
CS 6113 Program Visualization and Monitoring
CS 6363 Advanced Compiler Construction
CS 6513 Advanced Computer Architecture
CS 6523 Distributed Operating Systems
CS 6543 Computer Networks
CS 6593 Advanced Topics in Distributed Systems

2. High-Performance Computational Techniques Focus:

The following two courses:
CS 5603 Numerical Analysis
CS 6613 Parallel Numerical Methods and Software

Plus two courses from the following:
CS 6103 Distributed Software Development
CS 6243 Machine Learning
CS 6253 Topics in Neural Networks
CS 6693 Advanced Topics in Application Development
CS 6723 Image Processing

C. Free Electives (9 semester credit hours):

Selected from computer science and related areas with approval of the Graduate Advisor

D. Computer Science Research (30 semester credit hours):

CS 7123 Research Seminar (6 hours)
CS 7211-3 Doctoral Research (12 hours)
CS 7311-3 Doctoral Dissertation (12 hours)

Applicants with a M.S. in Computer Science from another college or university may apply a maximum of 12 hours of previously earned graduate credits toward their doctoral degree. Each student's transcript will be evaluated by the Doctoral Studies Committee, and credit will be designated on a course-by-course basis to satisfy the formal coursework requirements of the degree.

Advancement to Candidacy. All students seeking a doctoral degree must be admitted to candidacy. One of the requirements for admission to candidacy is passing a doctoral qualifying examination. Students should consult the University's Doctoral Degree Regulations for the other requirements.

Qualifying Exam. The qualifying examination is divided into written and oral portions.

Written Portion of the Qualifying Examination. The written portion of the doctoral qualifying examination (written exam) is scheduled at the beginning of the Fall and Spring Semesters. Full-time doctoral students must take the written
exam by the beginning of their third semester. Normally, the written exam is taken at the start of the student's second year at the beginning of the Fall Semester. Students who fail their first attempt at the written exam are allowed to make a second attempt on the next written exam. No more than two attempts to pass the written exam are permitted.

**Oral Portion of the Qualifying Examination.** After the student has completed the coursework in the student's proposed program of study (core courses, designated electives, and free electives), the next step is the oral portion of the qualifying examination. The oral exam will be conducted by a faculty committee, which is chaired by the student's program advisor. The format of the oral exam will consist of a presentation of the student's dissertation proposal, followed by a period of questioning based on the dissertation proposal and the student's proposed program of study. Unanimous approval of the examination committee is required to pass the oral exam. No more than two attempts to pass the oral exam will be permitted. The oral exam must be taken within one year after completion of all coursework.

**Doctoral Dissertation and Final Oral Examination.** After passing the qualifying examination, the next steps are writing a dissertation and passing the final oral examination. The final oral examination is administered and evaluated by the student's dissertation committee and covers the dissertation and the general field of the dissertation. The final oral examination will consist of an open presentation of the dissertation, followed by a closed oral examination. Unanimous approval of the Dissertation Committee is required to pass the final oral examination. Also, the written dissertation must be unanimously approved by the Dissertation Committee.

**COURSE DESCRIPTIONS**

**COMPUTER SCIENCE**

(CS)

5003  **Computer Literacy**  
(3-0) 3 hours credit.  
This course is designed for educators who need a basic computer course so that intelligent decisions may be made concerning the issues of computers in the classroom. Students will have the opportunity to learn the vocabulary, workings, and capabilities of the computer and programming in **BASIC** and **Pascal** languages. May not be applied toward the Master of Science degree or Doctor of Philosophy degree in Computer Science.

5023  **Computers for Teachers**  
(3-0) 3 hours credit.  
A course for mathematics teachers on integrating the computer into the mathematics curriculum, with an algorithmic-oriented introduction to computer programming in **BASIC** and **Pascal**. This course can only be applied to graduate majors in mathematics with a concentration in Mathematics Education. (Same as **MAT** 5013. Credit cannot be earned for both **MAT** 5013 and **CS** 5023.)
5103 **Software Engineering**  
(3-0) 3 hours credit. Prerequisites: CS 2734 and 3343.  
Discussion of issues relevant to the development of large software systems, such as specification, design and synthesis of reliable software, proof of correctness, self-checking software, reconfiguration, recovery, fault-tolerant systems, and system reliability modeling.

5113 **Computer Graphics**  
(3-0) 3 hours credit. Prerequisites: CS 3343 and MAT 2233.  
The course emphasizes generative computer graphics, interactive construction of graphic objects, data base design, composite object construction, and hidden-surface algorithmic techniques. Specifically, the emphasis is on vector graphic devices and on the production of high-resolution images.

5233 **Artificial Intelligence**  
(3-0) 3 hours credit. Prerequisite: CS 3323 and 3343.  
This course covers artificial intelligence from the standpoint of general problem-solving techniques. Major topics covered include search, knowledge representation, planning, machine learning, and natural language processing. Programming projects will be in LISP.

5253 **Expert Systems**  
(3-0) 3 hours credit. Prerequisite: CS 5233.  
This course presents an in-depth study of the area of artificial intelligence known as expert systems. Example expert systems will be examined as a means of identifying the generally accepted methodologies for developing such systems as well as the basic research issues involved.

5293 **Numerical Linear Algebra**  
(3-0) 3 hours credit. Prerequisite: MAT 3633 or an equivalent.  
Direct and iterative methods for solving general linear systems, the algebraic eigenvalue problem, least square problems, and solutions of sparse systems arising from partial differential equations. (Same as MAT 5293. Credit cannot be earned for both CS 5293 and MAT 5293.)

5353 **Formal Languages, Automata, and Theory of Computation**  
(3-0) 3 hours credit. Prerequisites: CS 3343 and 3233.  
Formal models of computation and syntax.

5363 **Structure of Programming Languages and Compilers**  
(3-0) 3 hours credit. Prerequisite: CS 3343 and 3233.  
A study of modern programming languages with emphasis on their implementation. Topics include scanning, parsing, syntax-directed translation, code generation, and optimization. (Formerly CS 5303. Credit cannot be earned for both CS 5363 and CS 5303.)

5443 **Data Base Management**  
(3-0) 3 hours credit. Prerequisites: CS 3233 and 3743.  
Design and implementation of techniques for information retrieval in data base management systems.
**5513**  **Computer Architecture**  
(3-0) 3 hours credit. Prerequisites: CS 3733 and 4753. Study of modern computer architecture, including parallel computers, multiprocessors, pipelines, and fault tolerance.

**5523**  **Operating Systems**  
(3-0) 3 hours credit. Prerequisite: CS 5513. Operating systems concepts with emphasis on concurrency, resource management, and distributed systems.

**5603**  **Numerical Analysis**  
(3-0) 3 hours credit. Prerequisite: MAT 3633 or consent of instructor. Emphasis on the mathematical analysis of numerical methods. Areas of study include solution of nonlinear equations and function optimization, approximation theory, and numerical quadrature. (Same as MAT 5603. Credit cannot be earned for both CS 5603 and MAT 5603.)

**5623**  **Simulation Techniques**  
(3-0) 3 hours credit. Prerequisites: CS 1723 and STA 3523, or consent of instructor. Techniques in simulation on a digital computer. Generation of random numbers from a distribution, Monte Carlo techniques, and use of simulation languages. Development of simulation models for specific problems.

**5633**  **Analysis of Algorithms**  
(3-0) 3 hours credit. Prerequisite: CS 3233. Models of computation, design techniques such as divide-and-conquer and dynamic programming, graph algorithms, and sets and union-find. Additional topics chosen from pattern matching, integer and polynomial arithmetic, and the fast Fourier transform.

**5973**  **Directed Research**  
(3-0) 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record in which the course is offered. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

**6103**  **Distributed Software Development**  
(3-0) 3 hours credit. Prerequisites: CS 5103 and 5523. Development and management of distributed software, including cooperative tools and CASE. The course considers the aspects of managing the configuration of software during its life cycle. Topics include identification, control, auditing, and status accounting. Simulation of a configuration control board process.
6113 Program Visualization and Monitoring  
(3-0) 3 hours credit. Prerequisite: CS 5113 or consent of instructor.  
Concepts and techniques of software instrumentation. Window systems  
programming for postmortem and real-time visualization of program  
behavior. Applications of visual execution monitors in performance  
evaluation and debugging.

6133 Software Specification and Verification  
(3-0) 3 hours credit. Prerequisite: CS 5633.  
This course focuses on languages for specification of programs as well as  
on verification techniques for sequential, concurrent, and distributed  
programs.

6243 Machine Learning  
(3-0) 3 hours credit. Prerequisite: CS 5233.  
This course studies machine learning techniques in the area of artificial  
intelligence. Major topics covered include inductive learning, unsupervised  
learning, speedup learning, and computational learning theory.

6253 Topics in Neural Networks  
(3-0) 3 hours credit. Prerequisite: Graduate standing.  
Analysis of neural networks. Topics may be selected from biological nervous  
systems and learning, threshold logic units, perceptrons, spatial and  
temporal associative memories, Hopfield nets, backpropagation, Boltzmann  
machines, Kohonen networks, the Neocognitron, and mathematical models  
of neural systems. Advanced topics might include neural network design,  
competitive learning, the CMAC model, adaptive resonance theory,  
bidirectional associative memories, Kanerva self-propagating search,  
advanced simulated annealing, neurocomputer implementations, and  
advanced genetic algorithms. May be repeated for credit when topics vary.

6363 Advanced Compiler Construction  
(3-0) 3 hours credit. Prerequisite: CS 5363.  
Areas of study include code generation techniques for vector machines and  
multiprocessors, implementation of higher-level imperative and functional  
languages, and run-time system support for distributed programming  
languages.

6453 Advanced Topics in Data Base Systems  
(3-0) 3 hours credit. Prerequisite: CS 5443.  
This course covers topics related to design and implementation (especially  
optimization, concurrency, integrity, and security) of distributed data bases,  
heterogeneous data bases, and object-oriented data bases. It also explores  
current research topics in data bases.

6513 Advanced Architecture  
(3-0) 3 hours credit. Prerequisites: CS 5513 and 5523.  
Areas of study include advanced architectures, including massively parallel  
and distributed systems. Issues of communication, fault tolerance, and  
performance are addressed.

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6523 Distributed Operating Systems  
(3-0) 3 hours credit. Prerequisites: CS 5513 and 5523.  
Distributed operating systems issues, including migration, naming,  
reliability, security, resource allocation, and scheduling are addressed in  
heterogeneous and homogeneous systems. Time-critical data such as video  
and audio are considered.

6543 Networks  
(3-0) 3 hours credit. Prerequisite: CS 5523.  
State-of-the-art transmission media, interfaces, and protocols are addressed.  
ATM, FDDI, Sonet, BISDN, and other evolving standards are discussed.

6553 Performance Evaluation  
(3-0) 3 hours credit. Prerequisites: CS 5523 and 5513.  
Performance modeling, analysis, simulation, and measurement.

6593 Advanced Topics in Distributed Systems  
(3-0) 3 hours credit.  
Advanced topics in distributed systems. May be repeated for credit when  
topics vary.

6613 Parallel Numerical Methods and Software  
(3-0) 3 hours credit. Prerequisites: CS 5603 and 6643.  
The major goal of this course is to introduce students to the methods, tools,  
and ideas of parallel numerical computation. Important scientific application  
development and the basic methods for their solutions are addressed. Relevant  
mathematical software is reviewed and its use is outlined. Extensive  
examples and case studies are given. Techniques of constructing parallel  
numerical software are studied.

6643 Parallel Processing  
(3-0) 3 hours credit. Prerequisites: CS 5513 and 5523.  
Parallel models of computation, performance measurement, and modeling  
of parallel algorithms and application studies on parallel computers.

6653 Parallel Algorithms  
(3-0) 3 hours credit. Prerequisites: CS 5513 and 5633.  
Theoretical analysis of parallel algorithms and models. Studies of the fastest  
and most efficient parallel algorithms for a variety of problems. Emphasis  
is on fundamental results and techniques and on rigorous analysis of  
algorithmic performance. The structures and mapping relationships between  
the dominant network architectures and algorithms are also covered.

6693 Advanced Topics in Application Development  
(3-0) 3 hours credit. Prerequisite: Consent of instructor.  
Advanced applications in applications development. May be repeated for  
credit when topics vary.
6723  **Image Processing**  
(3-0) 3 hours credit. Prerequisite: CS 5523.  
Topics include image acquisition, enhancement, transformations, filters,  
compression, segmentation and edge detection, morphology, and  
recognition.

6953  **Independent Study**  
3 hours credit. Prerequisite: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6961  **Comprehensive Examination**  
1 hour credit. Prerequisite: Approval of the appropriate graduate studies committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

6973  **Special Problems**  
(3-0) 3 hours credit. Prerequisite: Consent of instructor.  
An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6983  **Master's Thesis**  
3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director.  
Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.

7123  **Research Seminar**  
(3-0) 3 hours credit. Prerequisite: Permission of instructor.  
Presentation and analysis of literature in a selected area of research. May be repeated, but only 6 hours will count toward the Ph.D. degree requirements.

7211-3  **Doctoral Research**  
1 to 3 hours credit. Prerequisite: Admission to candidacy for doctoral degree. May be repeated for credit, but no more than 12 hours may be applied to the Ph.D. degree requirements. (Formerly CS 7243.)
Doctoral Dissertation

1 to 3 hours credit. Prerequisite: Admission to candidacy for doctoral degree. May be repeated for credit, but no more than 12 hours may be applied toward the Ph.D. degree requirements. (Formerly CS 7693.)
DIVISION OF EARTH AND PHYSICAL SCIENCES

Master of Science Degree in Chemistry

The purpose of the Master of Science degree program in Chemistry is to offer the student the opportunity to acquire a sound preparation of the fundamentals in several areas of chemistry, to introduce the student to recent advances in chemical theory and methods, and to encourage research in a specific area of study.

Graduate study in chemistry is offered leading to the M.S. degree with the following interest areas: analytical and environmental chemistry, bioorganic chemistry, biophysical chemistry, inorganic chemistry, organic chemistry, physical chemistry, and chemical physics.

Faculty expertise in each of the interest areas offers the opportunity for direct student-faculty interaction for thesis development through coursework and research. Additional cooperative projects and programs are available with other area research institutions.

Qualified students are encouraged to apply for teaching and/or research assistantships and fellowships. Requests should be sent to the Director of the Division of Earth and Physical Sciences at the same time application is made for admission to UTSA.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, a candidate for the Master of Science degree in Chemistry must complete or have completed a minimum of 24 undergraduate semester hours in chemistry, of which 12 or more must be upper-division courses. Included in the undergraduate chemistry requirement are two semesters each of both organic and physical chemistry with the appropriate laboratories. All undergraduate chemistry courses must be completed with a grade-point average of 3.0 or higher.

All applicants must submit scores from the Graduate Record Examination aptitude test (GRE).

A minimum of two letters of recommendation from persons familiar with the applicant's undergraduate scholastic record must be sent directly to the Division of Earth and Physical Sciences at the same time application is made for admission to UTSA.

Thesis Option in Chemistry

Degree Requirements. The Master of Science program requires the successful completion of a minimum of 34 semester credit hours. The following plan must be followed by all candidates:

A. Required Courses (25 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 5113</td>
<td>Advanced Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHE 5133</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHE 5163</td>
<td>Advanced Instrumental Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CHE 5192</td>
<td>Advanced Spectral Measurement and Interpretation I</td>
<td>2</td>
</tr>
</tbody>
</table>

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CHE 5202  Advanced Spectral Measurement and Interpretation II  2 hours
CHE 5213  Chemical Thermodynamics  3 hours
CHE 5271  Graduate Seminar in Chemistry  3 hours
CHE 6983  Master's Thesis, including an oral defense of the written thesis  6 hours

Registration for the Graduate Seminar in Chemistry is required for each semester of residence, although no more than 3 semester credit hours can be applied to the master's degree.

B. A minimum of 6 semester credit hours of electives in chemistry, as approved by the Graduate Advisor of Record, is required.

The following interest areas are available for study:

Analytical and Environmental Chemistry
Bioorganic Chemistry
Biophysical Chemistry
Inorganic Chemistry
Organic Chemistry
Physical Chemistry and Chemical Physics

C. A minimum of 3 semester credit hours of supportive electives are required in chemistry, advanced mathematics, computer science, earth and physical sciences, and/or biology as approved by the Graduate Advisor of Record.

D. Students must successfully defend their thesis research results before their graduate committee prior to the submission of the thesis to the Vice President for Academic Affairs for approval.

Nonthesis Option in Chemistry

Degree Requirements: This program requires the successful completion of a minimum of 37 semester credit hours. All candidates for the degree must complete the following:

A. Required Courses (25 semester credit hours):

<table>
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<tr>
<th>Code</th>
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<tr>
<td>CHE 5192</td>
<td>Advanced Spectral Measurement and Interpretation I</td>
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</tr>
<tr>
<td>CHE 5271</td>
<td>Graduate Seminar in Chemistry</td>
<td>3 hours</td>
</tr>
<tr>
<td>CHE 5973</td>
<td>Directed Research</td>
<td>6 hours</td>
</tr>
</tbody>
</table>
Registration for the Graduate Seminar in Chemistry is required for each semester of residence, although no more than 3 semester credit hours can be applied to the degree.

B. 6 semester credit hours of laboratory work in chemistry in two distinctly different areas, normally to be taken as Independent Study and completed prior to enrolling in CHE 5973.

C. 6 semester credit hours of elective organized course support work within the College of Sciences and Engineering, as approved by the Graduate Advisor of Record.

D. Students must pass a final oral comprehensive examination, scheduled during the student’s last semester of work, for completion of the degree program.

COURSE DESCRIPTIONS
CHEMISTRY
(CHE)

5113 Advanced Organic Chemistry I
(3-0) 3 hours credit. Prerequisites: 8 hours each of undergraduate organic chemistry and physical chemistry or graduate standing in chemistry. An advanced study of topics in organic chemistry such as stereochemistry, conformational analysis, nonbenzenoid aromaticity, and organic reaction mechanisms.

5133 Advanced Inorganic Chemistry
(3-0) 3 hours credit. Prerequisite: CHE 4263 or an equivalent. Modern theories of chemical bonding, structure of inorganic compounds, reaction mechanisms, organometallic chemistry, and cluster compounds.

5163 Advanced Instrumental Analysis
(3-0) 3 hours credit. Prerequisites: CHE 3224 and 3243 or an equivalent. The physical and chemical principles of modern instrumental techniques used for chemical analysis, with emphasis on absorption, emission, magnetic resonance, and Raman spectroscopies; mass spectrometry; chromatography; and electrochemical techniques.

5192 Advanced Spectral Measurement and Interpretation I
(0-6) 2 hours credit. Prerequisites: CHE 5163, 3243, and 4373 or their equivalents; or consent of the instructor. Corequisite: CHE 5973, 6951-3, or 6983. Enrollment will normally be limited to M.S. degree-seeking students. A regularly scheduled topics course including experimentation, data analysis, and problem solving using modern chemical instrumentation. In CHE 5192 and CHE 5202, students must demonstrate basic competency in a minimum of three of the following: FT-NMR, FT-IR, UV-vis and fluorescence, mass spectrometry, computer-based chemical modeling, gas and liquid chromatography, and spectral data analysis. May be repeated.

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for credit with the approval of the Graduate Advisor of Record when the topics vary, although not more than 2 semester credit hours can be applied to the master’s degree.

**5202 Advanced Spectral Measurement and Interpretation II**
(0-6) 2 hours credit. Prerequisites: CHE 5163, 3243, and 4373 or their equivalents; or consent of the instructor. Corequisite: CHE 5973, 6951-3, or 6983. Enrollment will normally be limited to M.S. degree-seeking students.

A complement to CHE 5192. A regularly scheduled topics course including experimentation, data analysis, and problem solving using modern chemical instrumentation. In CHE 5192 and CHE 5202, students must demonstrate basic competency in a minimum of three of the following: FT-NMR, FT-IR, UV-vis and fluorescence, mass spectrometry, computer-based chemical modeling, gas and liquid chromatography, and spectral data analysis. May be repeated for credit with the approval of the Graduate Advisor of Record when the topics vary, although not more than 2 semester credit hours can be applied to the master’s degree.

**5213 Chemical Thermodynamics**
(3-0) 3 hours credit. Prerequisites: 8 hours each of undergraduate organic chemistry and physical chemistry or graduate standing in chemistry.

An advanced study of chemical thermodynamics. Discussion of chemical, electrochemical, and interphase equilibria.

**5223 Chemical Kinetics**
(3-0) 3 hours credit. Prerequisite: CHE 3224 or an equivalent.

An advanced study of topics in chemical kinetics, such as formal kinetics, theory of rates of chemical reactions, and reaction mechanisms.

**5243 Quantum Chemistry**
(3-0) 3 hours credit. Prerequisites: CHE 4253 and MAT 2213, or consent of instructor.

A study of concepts and methods of quantum mechanics, with emphasis on the nature of the chemical bond and the interaction of electromagnetic radiation with molecules.

**5271 Graduate Seminar in Chemistry**
(0-3) 1 hour credit. Prerequisite: Graduate standing in chemistry or consent of the Graduate Advisor of Record.

Current research and literature seminars presented by faculty, visiting lecturers, and master’s candidates. Chemistry master’s-degree-seeking students must register every semester while in residence, but only 3 hours will apply toward the master’s degree.

**5503 Bioorganic Chemistry**
(3-0) 3 hours credit. Prerequisite: CHE 5113 or consent of the instructor.

Chemical transformations of biologically important organic compounds; examination of enzyme active sites. Discussion of theories of catalysis, stereochemistry, electron-transfer, and molecular structure in the context of biological systems.
Biophysical Chemistry
(3-0) 3 hours credit. Prerequisites: CHE 5113 and CHE 5213, or consent of the instructor.
Physical chemistry of natural macromolecular systems. Spectroscopy: UV Visible and CD spectroscopy of proteins and nucleic acids; fluorescence of proteins, nucleic acids, and extrinsic labels; nuclear and electron magnetic resonance of enzymes and cell membranes. Thermodynamics of macromolecular interactions; linked functions and allosteric models.

Statistical Thermodynamics
(3-0) 3 hours credit. Prerequisite: CHE 3224 or an equivalent.
A molecular approach to the study of the physico-chemical properties of gases, liquids, and solids. A molecular study of chemical and interphase equilibria.

Teaching Seminar
(1-2) 2 hours credit. Prerequisite: Graduate standing in Chemistry and concurrent designation as a teaching assistant in the Chemistry Program of the Division of Earth and Physical Sciences, or consent of instructor.
The course is designed to improve the instructional effectiveness of graduate students' teaching at the college level. The course will cover but is not limited to board-work, clear speech, teacher-student interaction, professional responsibilities, course content and pace, grading policy, quiz writing, sensitivity training to student needs, information on technical support, and guest lecturers on special topics. The grade report for the course is either CR (satisfactory performance) or NC (unsatisfactory performance). May be repeated when the topics vary. This course may not be applied as credit toward any M.S. degree in the Division of Earth and Physical Sciences.

Directed Research
3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record.
The directed research course may involve either a laboratory or a theoretical problem. Normally a written report is required. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

Advanced Organic Chemistry II
(3-0) 3 hours credit. Prerequisite: CHE 5113 or consent of instructor.
Study of organic reaction mechanisms.

Methods of Organic Synthesis
(3-0) 3 hours credit. Prerequisite: CHE 5113 or consent of instructor.
A study of modern methods of organic functional group transformation and of simple carbon skeleton construction; introduction to the synthon concept and to retrosynthetic analytical methodology for designing rational synthetic approaches to complex organic molecules.
6153  **Advanced Topics in Inorganic and Physical Chemistry**  
(3-0) 3 hours credit. Prerequisites: Consent of instructor and Graduate Advisor of Record.  
An organized course offering the opportunity for a specialized study of advanced aspects of inorganic and/or physical chemistry. The course may be repeated for credit, but not more than 6 hours may be applied to the master's degree.

6163  **Advanced Topics in Analytical and Structural Chemistry**  
(3-0) 3 hours credit. Prerequisites: Consent of instructor and Graduate Advisor of Record.  
An organized course offering the opportunity for a specialized study of advanced techniques of chemical analysis and/or determination of molecular structure. The course may be repeated for credit, but not more than 6 hours may be applied to the master's degree.

6173  **Advanced Topics in Organic, Medicinal, Bioorganic, and Biophysical Chemistry**  
(3-0) 3 hours credit. Prerequisites: Consent of instructor and Graduate Advisor of Record.  
An organized course offering the opportunity for a specialized study of advanced aspects in organic, medicinal, bioorganic, and/or biophysical chemistry. The course may be repeated for credit, but not more than 6 hours may be applied to the master's degree.

6183  **Topics in the Chemistry of Natural Products**  
(3-0) 3 hours credit. Prerequisites: CHE 5113 and CHE 6123; CHE 5503 is recommended.  
Selected topics in the chemistry and biochemistry of natural products and related compounds of biological and medicinal interest. Course may be repeated for credit when topics vary, but no more than 6 hours may apply to the master's degree.

6903  **Progress in Chemistry**  
(3-0) 3 hours credit. Prerequisite: Consent of instructor.  
An organized course offering the opportunity for a specialized study of current aspects of chemistry not normally available as part of the regular course offerings. The course may be repeated for credit, but not more than 6 hours may be applied to the master's degree.

6951-3  **Independent Study**  
1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student’s graduate advisor of record.  
Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.
6961 Comprehensive Examination
1 hour credit. Prerequisite: Approval of the appropriate Graduate Studies Committee.
Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

6973 Special Problems
(3-0) 3 hours credit. Prerequisite: Consent of instructor.
An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, will apply to a master's degree.

6983 Master's Thesis
3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director.
Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.

Master of Science Degree in Environmental Sciences

The Master of Science degree in Environmental Sciences is available to students with undergraduate and/or graduate degrees in an engineering or scientific discipline from an accredited college or university. This program is designed for those individuals seeking initial or continuing preparation for careers involving the allocation, protection, regulation, and use of environmental resources.

Program Admission Requirements. In addition to the University-wide graduate admission requirements, a candidate for the Master of Science must satisfy the following requirements:

1. an overall grade-point average of 3.0 in the last 60 hours completed at the undergraduate level
2. submission of results on the Graduate Record Examination (GRE) or equivalent score on other relevant tests to the Office of Admissions and Registrar prior to consideration for admission
3. favorable recommendation by the Master of Science degree in Environmental Sciences Admissions Committee.

Those who do not meet these admissions requirements may be considered on an individual basis by the Environmental Sciences Admissions Committee.
Degree Requirements. The minimum number of semester credit hours required for this degree, exclusive of coursework or other study required to remove deficiencies, is 36. All candidates for the degree must complete

A. Required courses (21 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ES 5003</td>
<td>Environmental Systems Analysis</td>
</tr>
<tr>
<td>ES 5013</td>
<td>Instrumental Methods for Environmental Analysis</td>
</tr>
<tr>
<td>ES 5033</td>
<td>Data Processing in Environmental Planning and Management</td>
</tr>
<tr>
<td>ES 5203</td>
<td>Environmental Systems</td>
</tr>
<tr>
<td>ES 5403</td>
<td>Industrial Process</td>
</tr>
<tr>
<td>ES 5503</td>
<td>Environmental Regulations</td>
</tr>
<tr>
<td>ES 5803</td>
<td>Environmental Planning and Management</td>
</tr>
</tbody>
</table>

B. Elective courses (15 semester credit hours):

Elective courses must constitute a coherent program of scholarship. Each student's elective program must be prepared in consultation with and approved by the student's graduate committee prior to taking courses.

Option I: 15 semester credit hours of elective graduate coursework constituting a coherent program of scholarship with at least 9 semester credit hours at the advanced level (i.e., 6000-level courses) in environmental sciences. Up to 6 elective hours may be taken in disciplines outside environmental sciences. Prior approval of the Graduate Advisor of Record is required. Such outside coursework must clearly support the student's program of study.

Option II: 9–12 semester credit hours of graduate coursework in a single related discipline in which a student has the required prerequisites. Such outside coursework must support an area of specialization within environmental sciences, such as biology, chemistry, civil engineering, or geology. Also, 3–6 semester credit hours of coursework at the advanced level (i.e., 6000-level courses) in environmental sciences. Prior approval of the Graduate Advisor of Record is required.

Students who elect to write a master's thesis are required to enroll in ES 6983 each semester in which the thesis is in progress, but no more than 6 semester credit hours will apply to the degree.

C. All candidates for the degree are required to pass an oral comprehensive examination, which will be scheduled after a student has completed at least 30 semester credit hours of coursework.
COURSE DESCRIPTIONS
ENVIRONMENTAL SCIENCES
(ES)

5003  Environmental Systems Analysis
(3-0) 3 hours credit. Prerequisites: MAT 1033 and STA 1993 or their equivalent, or consent of instructor.
Introductory course in systems analysis emphasizing its application for the management of environmental and public systems. Problem formulation, mathematical modeling, and solution procedures will be discussed. Quantitative tools will include marginal analysis, classical optimization, linear programming, and dynamic programming, stressing both uses and limitations. (Formerly ENV 6603. Credit cannot be earned for both ES 5003 and ENV 6603.)

5013  Instrumental Environmental Methods for Environmental Analysis
(2-2) 3 hours credit. Prerequisite: One year of college chemistry or consent of instructor.
Use, as well as interpretation of results, of various analytical and instrumental techniques used to detect environmental pollutants. EPA-approved techniques are emphasized. (Formerly ENV 5013. Credit cannot be earned for both ES 5013 and ENV 5013.)

5033  Data Processing in Environmental Planning and Management
(2-2) 3 hours credit.
Application of the computer to environmental planning and management problems. The computer as a mapping device for graphical display of spatially related data and the use of relational data bases for these applications. Geographic Information Systems and other uses of the computer are included. (Formerly ENV 5033. Credit cannot be earned for both ES 5033 and ENV 5033.)

5203  Environment Systems
(3-0) 3 hours credit.
Atmosphere, lithosphere, hydrosphere, and biosphere are treated as interrelated systems. Human impact and interaction within and among these systems are studied. Preparation and evaluation of environmental impact statements and assessments are included. (Formerly ENV 5533. Credit cannot be earned for both ES 5203 and ENV 5533.)

5213  Environmental Geology
(3-0) 3 hours credit.
Geologic materials and processes as related to their influence on the human physical environment. Effects of landscape modification and geologic hazards such as earthquakes and landslides. Properties of minerals, rocks, and soils and geologic aspects of waste disposal and water resources are examined. (Course cannot be used for graduate credit by students in Geology. Formerly ENV 5363. Credit cannot be earned for both ES 5213 and ENV 5363.)
5403 **Industrial Process**  
(3-0) 3 hours credit.  
Introduces basic physical, chemical, and biological processes used to produce products. Examines specific industries with the goal of enabling students to understand industrial process design and operation well enough to assess them from the perspective of environmental management.

5493 **Water Pollution Control**  
(3-0) 3 hours credit.  
Principles and methods of water pollution control process design and operation; selection and optimization of total treatment processes as well as appurtenances and accessory equipments; and methods involved in the design process and the selection of the hardware. (Formerly ENV 6893. Credit cannot be earned for both ES 5493 and ENV 6893.)

5503 **Environmental Regulations**  
(3-0) 3 hours credit.  
Current environmental enabling acts and regulations are covered, with emphasis placed on federal acts, such as the National Environmental Policy Act, Clean Water Act, Resource Conservation and Recovery Act, and associated regulations. Management strategies for environmental compliance are also presented. (Formerly ENV 5003. Credit cannot be earned for both ES 5503 and ENV 5003.)

5613 **Economics of Environmental Resources**  
(3-0) 3 hours credit.  
A study of governmental and private programs to promote prudent, efficient use of natural resources by society. Cost-benefit analysis is utilized to evaluate alternate solutions in formulating policy. (Formerly ENV 6623. Credit cannot be earned for both ES 5613 and ENV 6623.)

5803 **Environmental Planning and Management**  
(3-0) 3 hours credit.  
Regional, state, and national efforts to plan for the allocation and use of environmental resources are analyzed. Focus is on the strengths and weaknesses of traditional planning processes and regulation mechanisms. Technical, economic, and institutional considerations that influence plan development, preparation, and implementation are covered, as are citizen participation and conflict resolution. Students will prepare in-depth case studies. (Formerly ENV 6653. Credit cannot be earned for both ES 5803 and ENV 6653.)

6003 **Risk and Decision Analysis**  
(3-0) 3 hours credit. Prerequisite: ES 5003 or consent of instructor.  
Advanced application of systems analysis to the solution of environmental problems and the building and solving of mathematical models. The role of analytical tools such as cost analysis, decision, and utility theory as they are applied to the efficient utilization of natural resources are also covered. (Formerly ENV 6903. Credit cannot be earned for both ES 6003 and ENV 6903.)
6203 Environmental Ecology
(3-0) 3 hours credit.
The impact of man's activities on the environment: their effect on water, land, animal, and human resources. An evaluation of present and future strategies to preserve a healthy environment. (Formerly ENV 6613. Credit cannot be earned for both ES 6203 and ENV 6613.)

6523 Professional Practice in Environmental Planning and Management
(3-0) 3 hours credit.
A study of the standards of environmental practice in the private and public sectors; professional ethics and responsibilities, proposals, contracts, mediation, professional liability, report preparation, and other considerations of professional practice are covered. (Formerly ENV 5023. Credit cannot be earned for both ES 6523 and ENV 5023.)

6813 Water Resources
(3-0) 3 hours credit.
Application of management principles to the efficient utilization of water resources by society. Study of water as a resource and its value, uses, and changing role over time. Formulation of public policy toward water resources is studied. (Formerly ENV 6813. Credit cannot be earned for both ES 6813 and ENV 6813.)

6823 Land Resources
(3-0) 3 hours credit.
The changing role of land as a resource as it relates to human and technological development. Land use and land-use planning in the rural-urban fringe is considered, as is the management of land as a resource in range, forestry, and agricultural production. (Formerly ENV 6823. Credit cannot be earned for both ES 6823 and ENV 6823.)

6853 Energy Resources
(3-0) 3 hours credit.
Energy utilization, energy resources development, availability of alternatives and energy resources management, conservation, and policy are presented. Applicable physical principles which relate to the economics, conservation, and technology of energy are covered. (Formerly ENV 6853. Credit cannot be earned for both ES 6853 and ENV 6853.)

6863 Air Quality Management
(3-0) 3 hours credit.
Introduction to the field of air pollution control: sources and physical, chemical, and biological effects of air pollutants. Overall objectives and systematic efforts to deal with air pollution, including air quality criteria; development of air quality standards; and plans for implementing them. (Formerly ENV 6863. Credit cannot be earned for both ES 6863 and ENV 6863.)
6873  Project Analysis
(3-0) 3 hours credit. Prerequisite: ES 5033 or consent of instructor.
This course will cover the complex processes and factors involved in the
evaluation of large-scale projects involving natural resources. It will bring
together tools required to evaluate the physical, economic, financial, legal,
and political constraints of such projects. (Formerly ENV 6873. Credit
cannot be earned for both ES 6873 and ENV 6873.)

6883  Solid Waste Management
(3-0) 3 hours credit. Prerequisite: ES 5003 or consent of instructor.
Practical aspects of solid waste management, with emphasis placed on
interrelationship of environmental, economic, institutional, and tech-
nological aspects of source reduction, recycling, waste to energy, and
perpetual care. (Formerly ENV 6883. Credit cannot be earned for both ES
6883 and ENV 6883.)

6951-3  Independent Study
1 to 3 hours credit. Prerequisites: Graduate standing and permission in
writing (form available) of the instructor and the student's graduate advisor
of record.
Independent reading, research, discussion, and/or writing under the
direction of a faculty member. For students needing specialized work not
normally or not often available as part of the regular course offerings. May
be repeated for credit, but not more than 6 hours, regardless of discipline,
will apply to the master's degree.

6961  Comprehensive Examination
1 hour credit. Prerequisite: Approval of the appropriate Graduate Studies
Committee to take the Comprehensive Examination.
Independent study course for the purpose of taking the Comprehensive
Examination. May be repeated as many times as approved by the Graduate
Studies Committee. Enrollment is required each term in which the
Comprehensive Examination is taken if no other courses are being taken
that term. The grade report for the course is either CR (satisfactory
performance on the Comprehensive Examination) or NC (unsatisfactory
performance on the Comprehensive Examination).

6963-6  Internship
3 to 6 hours credit.
An opportunity will be provided for the students to work in a setting which
permits them to apply the knowledge learned in the formal instruction part
of the program. May be repeated for credit, but not more than 6 hours will
apply to the master's degree.

6973  Special Problems
(3-0) 3 hours credit. Prerequisite: Consent of instructor.
An organized course offering the opportunity for specialized study not
normally or not often available as part of the regular course offerings. Special
Problems courses may be repeated for credit when the topics vary, but not
more than 6 hours, regardless of discipline, will apply to a master's degree.
6983 Master’s Thesis
3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the master’s degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.

Master of Science Degree in Geology

The purpose of the Master of Science degree program in Geology is to offer the student the opportunity for advanced study and research leading to the M.S. degree in the following emphasis areas: (1) Water Resources (Hydrogeology), (2) Environmental Geology, and (3) Applied Geology.

Qualified students are encouraged to apply for teaching and/or research assistantships and fellowships. Requests should be addressed to the Director of the Division of Earth and Physical Sciences at the same time application is made for admission to UTSA.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, applicants are expected to have completed an undergraduate degree in geology (equivalent to UTSA’s) or a bachelor’s degree in chemistry, physics, mathematics, computer science, life sciences, or engineering from an accredited institution of higher education. Applicants with deficiencies in their academic background are required to consult with the Graduate Advisor of Record to establish an acceptable program of study with the approval of the graduate faculty. In such cases, students should anticipate that additional time will be required to complete the degree.

All applicants must submit scores from the Graduate Record Examination aptitude test (GRE). Three letters of recommendation should be sent to the Director, Division of Earth and Physical Sciences.

Thesis Option in Geology

Degree Requirements. The Master of Science program in Geology requires the successful completion of a minimum of 33 semester credit hours.

All candidates for the degree must complete

A. 8 semester credit hours minimum in the geology core curriculum:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO 5991</td>
<td>Graduate Seminar in Geology</td>
<td>2 hours</td>
</tr>
<tr>
<td>GEO 6983</td>
<td>Master’s Thesis</td>
<td>6 hours</td>
</tr>
</tbody>
</table>

No more than 2 semester credit hours of Graduate Seminar and 6 semester credit hours of Master’s Thesis can be applied to the master's degree.
B. Candidates must choose one of the following three emphases:

**Water Resources Emphasis (Hydrogeology):**

12 semester credit hours minimum, to include the following courses:
- GEO 5603 Hydrogeology
- GEO 5703 Advanced Hydrogeology
- GEO 6203 Aqueous Geochemistry
- GEO 6603 Subsurface Fluid Mechanics

13 semester credit hours minimum, selected from the graduate course offerings in geology, environmental sciences, civil engineering, and biology with approval of the Graduate Advisor of Record

**Environmental Geology Emphasis:**

6 semester credit hours in
- GEO 5203 Advanced Environmental Geology
- GEO 5303 Advanced Geomorphology

10 semester credit hours minimum, selected from the graduate course offerings in geology

9 semester credit hours minimum, selected from the graduate course offerings in the College of Sciences and Engineering

**Applied Geology Emphasis:**

25 semester credit hours minimum, selected from graduate course offerings with the approval of the Graduate Advisor of Record

**Nonthesis Option in Geology**

The Nonthesis Option in Geology applies only to the (1) Water Resources (Hydrogeology) and (2) Environmental Geology emphases.

**Degree Requirements.** The Master of Science program in Geology requires the successful completion of a minimum of 39 semester credit hours.

All candidates for the degree must complete

A. 5 semester credit hours minimum in the geology core curriculum:

- GEO 5991 Graduate Seminar in Geology 2 hours
- GEO 5973 Directed Research 3 hours

No more than 2 semester credit hours of Graduate Seminar and 3 semester credit hours of Directed Research can be applied to the master's degree
B. Candidates must choose one of the following two emphases:

**Water Resources Emphasis (Hydrogeology):**

12 semester credit hours minimum, to include the following courses:
- GEO 5603 Hydrogeology
- GEO 5703 Advanced Hydrogeology
- GEO 6203 Aqueous Geochemistry
- GEO 6603 Subsurface Fluid Mechanics

22 semester credit hours minimum, selected from the graduate course offerings in geology, environmental sciences, civil engineering, and biology with approval of the Graduate Advisor of Record

**Environmental Geology Emphasis:**

6 semester credit hours minimum, to include the following courses:
- GEO 5203 Advanced Environmental Geology
- GEO 5303 Advanced Geomorphology

10 semester credit hours minimum, selected from the graduate course offerings in geology

18 semester credit hours minimum, selected from the graduate course offerings in geology, environmental sciences, civil engineering, chemistry, and biology with approval of the Graduate Advisor of Record

C. Under special circumstances, students may take up to 6 hours of upper-division undergraduate work within the College of Sciences and Engineering with approval of the Graduate Advisor of Record

D. All candidates are required to pass an oral comprehensive examination, which will be scheduled after a student has completed at least 30 semester credit hours of coursework. GEO 6961: Comprehensive Examination (1 hour) does not contribute toward the 39-semester-credit-hour minimum.

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**COURSE DESCRIPTIONS**

**GEOLOGY**

(GEO)

**5203 Advanced Environmental Geology**

(3-0) 3 hours credit. Prerequisite: GEO 4063 or consent of instructor.
Study of the geology of the environment, with emphasis on the physical and social effects of catastrophic geologic processes on engineered structures.

**5303 Advanced Geomorphology**

(3-0) 3 hours credit. Prerequisites: GEO 4113 and 4121, or consent of instructor.
Interpretation of landforms, with emphasis on mechanics of surficial processes and the relationship to type of rock material, structure, and climate.
5423  **Advanced Mineralogy**  
(2-3) 3 hours credit. Prerequisite: GEO 3043, 3052, or consent of instructor. Study of crystal chemistry, thermodynamics, and phase equilibria of various mineral groups; petrology and paragenesis relationships will be examined. Field trips required.

5454  **Advanced Paleontology**  
(3-3) 4 hours credit. Prerequisite: GEO 3083, 3123, 3131, or consent of instructor. Study of fossil assemblages, environmental significance of fossil associations, and reconstruction of depositional environments as related to the separation and differentiation of rock units in time and space. Field trips required.

5503  **Advanced Stratigraphy**  
(3-0) 3 hours credit. Prerequisite: GEO 3083, 3123, 3131, or consent of instructor. Chronologic study of stratigraphic systems, physical properties and facies, depositional and paleogeographic implications, correlation, nomenclature, and biostratigraphy. Field trips required.

5603  **Hydrogeology**  
(3-0) 3 hours credit. Prerequisite: GEO 4623 with a grade of "C" or better, or consent of instructor. Geologic principles governing the flow of ground water; emphasis on hydrology, flow system evolution and aquifer analysis. Field trips required.

5703  **Advanced Hydrogeology**  
(3-0) 3 hours credit. Prerequisites: GEO 5603 and consent of instructor. Numerical and analytical flow models, hydrogeochemical models, contaminant hydrogeology and contaminant transport.

5804  **Igneous-Metamorphic Petrology**  
(3-3) 4 hours credit. Prerequisite: GEO 3043, 3052, 3103, 3111, or consent of instructor. Origin and evolution of magmas. Origin and development of metamorphic grade, facies, and textures. Detailed study of igneous and metamorphic rock suites. Field trips required.

5853  **Mapping of Complex Geological Structures**  
(0-6) 3 hours credit. Prerequisites: GEO 4946 or an equivalent, and consent of instructor. Field study of an area of complex geology. Field mapping and written reports are required. May be repeated for credit up to a maximum of 6 hours when topic varies.

5894  **Advanced Structural Geology**  
(3-3) 4 hours credit. Prerequisite: GEO 3103, 3111, or consent of instructor. In-depth study of the various aspects of structural geology: stress and strain, behavior of materials, failure criteria, fault analysis, rheological properties of geologic materials, fold analysis, and subsurface analysis. Field trips required.
5904 **Carbonate Petrology**  
(3-3) 4 hours credit. Prerequisite: GEO 3043, 3052, 3123, 3131, or consent of instructor.  
Thin-section analysis and hand-specimen study of carbonate sediment and rocks, carbonate classifications, carbonate facies, models, and carbonate diagenesis. Field trips required.

5954 **Sandstone Petrology**  
(3-3) 4 hours credit. Prerequisite: GEO 3043, 3052, 3123, 3131, or consent of instructor.  
Thin-section analysis and hand-specimen study of clastic rocks, classifications, interpretation of provenance, clastic sedimentary facies, and clastic diagenesis. Field trips required.

5971-3 **Directed Research**  
1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student’s graduate advisor of record.  
The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the master's degree.

5991 **Graduate Seminar in Geology**  
(0-3) 1 hour credit. Prerequisite: Graduate standing in geology or consent of the Graduate Advisor of Record.  
Topical issues chosen by faculty and current research seminars presented by faculty, visiting lecturers, and master’s candidates. Only 2 hours may be applied toward the master’s degree.

6153 **Depositional Systems**  
(3-0) 3 hours credit. Prerequisite: GEO 5954 or consent of instructor.  
The processes, characteristics, and relationships among continental, transitional, and marine depositional systems; specific relationships that must be understood for each subsystem and how each subsystem relates to the global system. Field trips required.

6183 **Basin Analysis and Sedimentary Geology**  
(3-0) 3 hours credit. Prerequisite: GEO 6153 or consent of instructor.  
An interdisciplinary integration of geodynamics, mathematical and physical modeling, and sedimentary geology. Emphasizes basin formation, nature of the basin fill, maturation of the basin fill, and timing of events. Case histories of various basins will illustrate these various approaches.

6203 **Aqueous Geochemistry**  
(2-3) 3 hours credit. Prerequisite: GEO 3374 or consent of instructor.  
In-depth study and application of chemical concepts to geological problems; analyses of water-rock interaction at various temperatures and pressures.
6304  **Isotope Geology**  
(3-2) 4 hours credit. Prerequisite: GEO 3374.  
Geological applications of radioactive and stable isotopes; fundamentals of  
isotope fractionation processes in hydrology, metamorphism, and  
chronostratigraphy. Laboratory methods for stable isotope sample  
preparation and isotope ratio-mass spectrometry.

6403  **Advanced Geophysics**  
(3-0) 3 hours credit. Prerequisite: GEO 3383 or consent of instructor.  
Seismological and other geophysical methods and data for studying the  
physical and mechanical properties of the earth's crust, mantle, and core.

6603  **Subsurface Fluid Mechanics**  
(3-0) 3 hours credit. Prerequisites: MAT 2213 and consent of the instructor.  
Fluid properties, fluid dynamics, Navier-Stokes equations, laminar flow,  
stability, boundary-layer theory, and flow nets.

6803  **Electron Microscopy and Microbeam Analysis**  
(1-4) 3 credit hours. Prerequisite: Consent of instructor.  
Geological and geochemical applications of electron microscopy, X-ray  
microanalysis, and image analysis. The theory and development of electron  
imaging and analysis as well as case studies. The laboratory will focus on  
sample preparation, imaging, and elemental analysis.

6961  **Comprehensive Examination**  
1 hour credit. Prerequisites: Completion of at least 30 semester credit hours  
of coursework and approval of the appropriate Graduate Studies Committee  
to take the Comprehensive Examination.  
Independent study course for the purpose of taking the Comprehensive  
Examination. May be repeated as many times as approved by the Graduate  
Studies Committee. Enrollment is required each term in which the  
Comprehensive Examination is taken if no other courses are being taken  
that term. The grade report for the course is either CR (satisfactory  
performance on the Comprehensive Examination) or NC (unsatisfactory  
performance on the Comprehensive Examination).

6973  **Special Problems**  
(3-0) 3 hours credit. Prerequisite: Consent of the instructor.  
An organized course offering the opportunity for specialized study not  
normally or not often available as part of the regular course offerings. Special  
Problems courses may be repeated for credit when the topics vary, but not  
more than 6 hours, regardless of discipline, will apply to a master's degree.  
Field trips may be required.

6983  **Master's Thesis**  
3 hours credit. Prerequisites: Permission of the thesis director.  
Thesis research and preparation. May be repeated for credit, but not more  
than 6 hours will apply to the master's degree. Credit will be awarded upon  
completion of the thesis. Enrollment is required each term in which the  
thesis is in progress.
DIVISION OF ENGINEERING

Graduate programs in Engineering include the Master of Science in Civil Engineering, the Master of Science in Electrical Engineering, and the Master of Science in Mechanical Engineering. They offer opportunities for advanced study and research designed to prepare students for leadership roles in engineering careers with industry, government, or educational institutions. A thesis option is recommended for students who are planning a career in research or who contemplate pursuing a doctorate in one of the engineering disciplines. A nonthesis option is also available for students who desire a practical industrial applications-oriented degree.

Civil Engineering includes programs of study in structures, environmental sciences, systems, solid mechanics, and materials. Electrical Engineering includes programs of study in signal processing, digital systems, communications, instrumentation, and control systems. Mechanical Engineering includes programs of study in thermal and fluid systems, mechanical systems and design, solid mechanics, and materials.

A limited number of assistantships and fellowships are available to qualified students. All financial assistance is awarded on a competitive basis.

COURSE DESCRIPTIONS

ENGINEERING

(EGR)

5103 Advanced Topics in Engineering Analysis
(3-0) 3 hours credit. Prerequisite: MAT 3253 or an equivalent, or consent of instructor.
A comprehensive treatment of advanced methods of applied mathematics needed for the study of advanced courses in engineering. May be repeated for credit as topics vary.

5113 Advanced Engineering Economic Analysis
(3-0) 3 hours credit. Prerequisite: Graduate standing in Engineering.
Examination of the factors required to transform technological innovations into products. Elements of business planning are examined through a case-study approach.

5213 Topics in Systems Modeling
(3-0) 3 hours credit. Prerequisite: Graduate standing in Engineering.
Systems analysis approach to formulating and solving engineering problems. Topics include operational research, mathematical modeling, optimization, linear and dynamic programming, decision analysis, and statistical quality control.
Topic 3: Engineering Quality Control. Application of modern statistical quality-control methods to process simulation and manufacturing analysis. May be repeated for credit as topics vary.

5223 Topics in Materials Science  
(3-0) 3 hours credit. Prerequisite: Graduate standing in Engineering.  
Topic 2: Polymer Science. Introduction to plastics technology, processing, and manufacturing. RIM, pultrusions, forming operations, and fiber technology. Design methodologies, accelerated life prediction, constitutive and failure models. May be repeated for credit as topics vary.

5303 Continuum Mechanics  
(3-0) 3 hours credit. Prerequisite: EGR 2503 or an equivalent, or consent of instructor.  
Topic 1: Continuum Mechanics. Equations of Newtonian and non-Newtonian fluid motion, kinematics, conservation laws, linear and nonlinear constitutive equations; viscoelastic fluids; mechanics of suspensions; surface flow; viscometric flows.  
Topic 2: Advanced Continuum Mechanics. The essentials of finite deformation theory of solids and fluids to describe mechanical behavior of biological tissue.

5313 Fracture Mechanics  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Introduction to failure and fracture of engineering materials, including Griffith's energy balance, stress intensity, and strain energy release rate approaches to brittle fracture. Also, Dugdale and Irwin approaches to ductile fracture. Applications to modern engineering problems.

5323 Viscoelasticity  
(3-0) 3 hours credit. Prerequisites: EGR 3213 and MAT 3253 or an equivalent, or consent of instructor.  
Principle of fading memory, integro-differential constitutive laws, mechanical models, time and temperature superposition, and linear and nonlinear methods. Applications to polymers, composites, and adhesives.

5413 Composite Materials  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Introduction to mechanics of composites, micromechanics, macromechanics, lamination theory, design, and applications of fiber-reinforced composites and particulate composites.
5423 **Nonlinear Systems**  
(3-0) 3 hours credit. Prerequisite: MAT 3253 or equivalent, or consent of instructor.  
Characterization of systems exhibiting nonlinear behavior, analytical and computational techniques in solving systems of nonlinear differential equations, and computer application in algebraic manipulations.

5513 **Finite Element Methods in Mechanics**  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Derivation and implementation of the finite element method, including boundary value and time-dependent problems.

5533 **Topics in Solid Mechanics**  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Topic 2: Elasticity. Equilibrium, compatibility equations, strain energy methods, torsion of noncircular sections, flexure, and axially symmetric problems.  
Topic 3: Methods of Experimental Mechanics. The application of electronic transducers, laser interferometry, and optical techniques to measure response of mechanical systems.  
Topic 4: Theory of Plates and Shells. Static flexural response of thin, elastic, rectangular, and circular plates; exact (series) and approximate (Ritz) solutions; circular cylindrical shells, axisymmetric and nonaxisymmetric membrane theory, and shells of arbitrary shape.  
Topic 6: Foundations of Solid Mechanics. Variational mechanics, energy methods, elementary viscoelastic/plastic problems, and wave propagation. May be repeated for credit as topics vary.

5613 **New and Emerging Technologies**  
(3-0) 3 hours credit.  
Examines entrepreneurial and managerial perspectives on the process of technology innovation. Design is the organizing concept used to study the continuum from idea to sale of products/services that are spawned by innovators using new and emerging technologies. Seminar format, case study preparation, presentation, and cooperative learning will be defining characteristics of this course.

5623 **Issues in Engineering Management**  
(3-0) 3 hours credit.  
Examines issues facing managers of technology in terms of their implications for people. The context is the cycle from conception to use/disposal of products and services. The framework for analysis and synthesis will be ecological, historical, and institutional. Seminar format, issue paper
preparation and presentation, and cooperative learning will be defining characteristics of this course.

5901 Engineering Communications  
(1-0) 1 hour credit. Prerequisite: Graduate standing.  
Slides, transparencies, posters, and TRI-SPORT reports; latest hardware and software for visual and presentations; individual and group presentations; and class critiques.

Master of Science Degree in Civil Engineering

The Master of Science program in Civil Engineering is designed to provide civil engineering professionals with the opportunity to prepare for careers concerned with the critical problems of a multifaceted society. The scope of civil engineering education and research activities focuses on projects that are typically large and costly, with potentially profound environmental, social, and financial impacts.

Both a thesis and a nonthesis option are available.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements for unconditional admission, the applicants must have the following:

1. a satisfactory score, as specified by the Graduate Studies Committee for Civil Engineering, on the GRE general aptitude test
2. an undergraduate degree in civil engineering or a closely related field from an accredited institution of higher education, or proof of equivalent training at a foreign institution
3. a favorable recommendation by the Master of Science in Civil Engineering Admissions Committee.

A student who does not qualify for unconditional admission may be admitted on a conditional basis as determined by the Master of Science in Civil Engineering Admissions Committee.

Degree Requirements. The minimum number of semester credit hours required for the M.S. in Civil Engineering, in addition to any conditional course requirements, is 33 semester credit hours for the nonthesis option and 30 semester credit hours for the thesis option. At least 24 semester credit hours must be taken at UTSA. Candidates are required to pass a comprehensive examination and/or a thesis defense administered by the student’s advisory committee, chaired by a full-time graduate faculty member. Degree requirements are as follows:

<table>
<thead>
<tr>
<th>Thesis Option</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated Electives (approved by the chairman of the student’s advisory committee)</td>
<td>9</td>
</tr>
<tr>
<td>Electives chosen from courses offered by the College of Sciences and Engineering</td>
<td>15</td>
</tr>
</tbody>
</table>
Thesis 6

Total Semester Credit Hours Required 30

Nonthesis Option: Hours

Designated Electives (approved by the chairman of the student's advisory committee) 9
Electives chosen from graduate courses offered by the College of Sciences and Engineering 21
CE 5973 Special Project 3

Total Semester Credit Hours Required 33

COURSE DESCRIPTIONS
CIVIL ENGINEERING
(CE)

5113 Advanced Structural Analysis (3-0) 3 hours credit. Prerequisite: CE 3113 or an equivalent. Moment distribution, force-deformation relations, stiffness matrix method, prismatic and prismatic members, flexibility method, beam column, frame stability, and inelastic effects.

5123 Advanced Structural Design (3-0) 3 hours credit. Prerequisite: CE 3113, 3213, 3233, or an equivalent. Structural behavior, design of trusses, funicular structures; cables and arches; members in bending and compression; continuous structures; plate and grid structures; membrane and pneumatic structures; structural systems; and constructional approaches.

5213 Industrial Waste Treatment (3-0) 3 hours credit. Prerequisite: CE 3633 or consent of instructor. Survey of industrial wastewater characteristics, biological, chemical and physical treatment processes, selection of appropriate processes, and design principles.

5223 Solid Waste Engineering (3-0) 3 hours credit. Prerequisite: CE 4623 or consent of instructor. Basic concepts in planning, designing, and operating solid waste systems, with emphasis placed on state-of-the-art technology and the interrelationship of economic, environmental, and institutional aspects.

5233 Topics in Water Quality Control (3-0) 3 hours credit. Prerequisite: CE 3633 or an equivalent. Topic 1: Physical and Chemical Treatment Operations. Physical and chemical unit operations for water and wastewater treatment, with emphasis on treatment process combinations for drinking water supply.
Topic 2: Biological Treatment Operations. Application of principles of biological processes, fluid dynamics, and process engineering to define and solve water and wastewater treatment problems.

Topic 3: Stream Sanitation. Biological impact of pollution on the ecosystems of rivers and streams.

Topic 4: Groundwater Pollution Control. Control approach and transport mechanisms of pollutants in different types of aquifers.

May be repeated for credit as topics vary.

5243 Topics in Environmental Monitoring and Analysis
(2-3) 3 hours credit. Prerequisites: CHE 1303 and CE 3633.

Topic 1: Methods of Environmental Monitoring and Measurement. Functions, terminology, method development, and QA/QC for drinking, ground, and wastewater analysis; soil analysis; and air sampling and analysis, including EPA methods and industrial application.

Topic 2: Unit Process for Water Quality Control. Laboratory and pilot plant studies of physical, chemical, and biological processes for the treatment of wastewaters and sludges.

May be repeated for credit as topics vary.

5273 Hazardous Material Control
(3-0) 3 hours credit. Prerequisite: CE 3663 or consent of instructor.

Analysis of advanced or specialized hazardous waste treatment methods. Emphasis on physical, chemical, and biological processes in treatment of hazardous wastes and processing of treatment residuals. Definitions of problems and objectives and evaluation of alternatives for special cases. Development of concepts for preliminary process design. Design-oriented class project and field trips.

5313 Topics in Water Resource Engineering
(3-0) 3 hours credit. Prerequisite: CE 3713 or an equivalent.

Topic 1: Water Resources Systems Engineering. Applications of engineering systems and analysis techniques to the design of water systems.

Topic 2: Application of water quantity and water quality modeling in water resources planning.

Topic 3: Advanced Surface Water Hydrology. Statistical analysis of hydrologic data, frequency analysis of extreme events, maximum probable precipitation and floods, watershed hydrology, and hydrologic time series.

Topic 4: Advanced Hydraulic Engineering. Open-channel flow, sediment transport, and hydraulics for special structures.

Topic 5: Special Topics in Water Resources. Irrigation engineering, coastal engineering, conjunctive use, regime theories, universal soil loss equation, and other selected topics.

May be repeated for credit as topics vary.

5323 Topics in Construction Management
(3-0) 3 hours credit. Prerequisite: Graduate standing.

Topic 1: Large Project Management. Large engineering project implementation and optimization of manpower, schedule, and material.

Topic 2: Urban Project Management. Application of engineering fundamentals and analysis to urban construction activities.
Topic 3: Site Cleanup and Remediation. Methods of cleanup and remediation of industrial and hazardous waste sites.
Topic 4: Forensic Engineering. Construction responsibilities, risks, and quality control.
May be repeated for credit as topics vary.

**5333 Topics in Dynamics of Structures**
(3-0) 3 hours credit. Prerequisites: Graduate standing and consent of instructor.
Topic 1: Dynamics of Structures. Fundamentals of structural dynamics; single- and multiple-degrees-of-freedom structural systems; lumped and distributed parameters systems; undamped and damped motions; and response to general dynamic loading.
Topic 3: Design of Structures for Dynamic Loads. Static equivalent load design vs. dynamic load design, design of structures for general dynamic loading, seismic design of reinforced concrete and masonry buildings, and base isolation design.
Topic 4: Stability of Structures. Concepts of stability of structures; buckling of columns, beams, beam-columns, rigid frames, and plates; flexural-torsional buckling of columns and beams; design for buckling; and energy and numerical methods.
May be repeated for credit as topics vary.

**5343 Topics in Structures**
(3-0) 3 hours credit. Prerequisite: Graduate standing and consent of instructor.
Topic 1: Earthquake Engineering. Earthquake characteristics, seismic loads, elastic and inelastic response, analysis and design of buildings for earthquakes.
Topic 3: Prestressed Concrete. Theory, advantages, and limitations; various systems of prestressing.
Topic 4: Advanced Steel Design. Analysis and design of bolted and welded connections under eccentric and combined loads, stiffened and unstiffened connections, continuous beam-to-column connections, and design of steel buildings.
Topic 5: Design of Shell Structures. Analysis and design of cables, arches, plates, folded plates, domes, shell roofs, and shell walls.
Topic 6: Masonry Design. Material properties; masonry block properties; design of masonry beams, columns, walls, joints, retaining walls, and highrise buildings; construction techniques.
May be repeated for credit as topics vary.
5353  **Topics in Geotechnical Engineering**  
(3-0) 3 hours credit. Prerequisites: CE 3413, Graduate standing, and consent of instructor.

Topic 1: Advanced Soil Mechanics. A study of soil constitutive behavior and testing, including nonlinear elastic hyperbolic models, incremental plasticity, soil chemistry, shear strength, and consolidation theory. Soil testing includes triaxial tests, the direct shear test, and consolidation tests.

Topic 2: Advanced Foundation Engineering. A study of foundation engineering design, including excavation slopes and retaining walls, cofferdams, sheetpile walls, caissons, drilled shafts, piles, settlement control methods, engineered fills, and foundations on expansive soils.

Topic 3: Soil and Site Improvement. A study of techniques available to improve poor soils and marginal construction sites, including lime stabilization, stone columns, deep dynamic compaction, geogrid reinforcement, geotextiles, slurry walls, grouting, construction dewatering, wick drains, and HDPE liners.

Topic 4: Soil Dynamics and Foundation Vibrations. A study of single- and multiple-degree-of-freedom systems, foundation analogs, dynamic soil testing and field measurements, vibration isolation, foundation design, and liquefaction site assessment.

May be repeated for credit as topics vary.

5413  **Topics in Civil Engineering**  
(3-0) 3 hours credit. Prerequisites: Graduate standing and consent of instructor.


Topic 2: Advanced CE Technology Transfer. CE technology development and transfer for real-world problems.

Topic 3: Advanced CE Design. Project-oriented design course involving advanced CE knowledge and other engineering expertise.

Topic 4: Topics in Geotechnical Engineering. Advanced soil mechanics, advanced geotechnical engineering, soil mechanics theory, advanced soil testing, soil dynamics, and earthquake engineering.

May be repeated for credit as topics vary.

5513  **Topics in Transportation Engineering**  
(3-0) 3 hours credit. Prerequisite: Graduate standing.

Topic 1: Transportation Systems Design. Multimode transportation networks and systems design methods.

Topic 2: Urban Transit. Planning and implementation of mass transit systems, airports, streets, and highways to satisfy the needs of urban residents and urban-based businesses.

Topic 3: Urban Transportation Engineering. Traffic studies, scheduling and routing, design and construction; economic and environmental impacts.

May be repeated for credit as topics vary.
5813 **Risk and Decision Analysis in Civil Engineering**  
(3-0) 3 hours credit. Prerequisite: EGR 3713. 
Perspective of risk assessments, risk estimation, event tree analysis, fault tree analysis, risk classifications, risk acceptability, probabilistic modeling, anatomy of risks with revealed preference method, decisions under uncertainties, utility theory, multiattribute utility functions, and case studies.

5923 **Topics in Air Pollution Control**  
(3-0) 3 hours credit. Prerequisite: CE 4643 or consent of instructor. 
Topic 1: Air Quality Monitoring and Analysis. Measurement and monitoring methods, including various laboratory and process development procedures. 
Topic 2: Air Pollution Control Design. Design principles for pollution control equipment for both gaseous and particulate emissions. 
Topic 3: Air Resources. Various types and characteristics of industrial air emissions; survey and control approach. 
May be repeated for credit as topics vary.

5973 **Special Project**  
3 hours credit. Prerequisite: Permission in writing (form available) from the instructor and the student's graduate advisor of record. 
The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

5991 **Graduate Seminar**  
(1-0) 1 hour credit. Prerequisites: Graduate standing and consent of instructor. 
May be repeated for credit up to a limit of 2 credit hours.

6951-3 **Independent Study**  
1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record. 
Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6961 **Comprehensive Examination**  
1 hour credit. Prerequisite: Approval of the Civil Engineering Graduate Studies Committee to take the Comprehensive Examination. 
Independent study course for the purpose of taking the Comprehensive Examination. May be repeated for credit as many times as approved by the Civil Engineering Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).
6971-3 Special Problems
(1-0 to 3-0) 1 to 3 hours credit. Prerequisite: Consent of instructor.
An organized course offering the opportunity for specialized study not
normally or not often available as part of the regular course offerings. Special
Problems courses may be repeated for credit when topics vary, but not more
than 6 hours, regardless of discipline, may be applied to the master’s degree.

6983 Master’s Thesis
3 hours credit. Prerequisite: Consent of the Graduate Advisor of Record
and thesis director.
Thesis research and preparation. May be repeated for credit, but not more
than 6 hours will apply to the master’s degree. Credit will be awarded upon
completion of the thesis. Enrollment is required each term in which the
thesis is in progress.

Master of Science Degree in Electrical Engineering

The Master of Science program in Electrical Engineering is designed to offer students
the opportunity to prepare for leadership roles in careers with industry, government,
or educational institutions. A thesis option is offered for those students who desire
the opportunity to obtain some expertise in research. A nonthesis option is also
available for those students who desire a practical industrial applications–oriented
degree.

Program Admission Requirements. In addition to satisfying the University-wide
graduate admission requirements, applicants for admission as graduate degree-seeking
students must meet the following admission requirements:

Unconditional Admission

1. A total score of 1100 or better on the verbal and quantitative portions of the GRE
genral aptitude test.
2. A bachelor’s degree in electrical engineering from an ABET-accredited institution
of higher education.

Conditional Admission

1. Students with electrical engineering undergraduate degrees: GPA of at least 2.75
in the last 60 hours and total score of 1100 or better on the verbal and quantitative
portions of the GRE may result in conditional admission. Students must take
three graduate core courses and earn better than a 3.0 in those courses before
unconditional admission to the graduate program may be granted.
2. Students with science or other engineering undergraduate degrees: Such students
may take 6 hours (4000-level) of undergraduate EE courses for graduate credit
in lieu of the courses outside of EE and must take four of the five graduate core
courses in EE.
   a) A minimum GPA of 3.0 or better in the last 60 hours and a GRE of 1100 or
   better on the verbal and quantitative portions may result in conditional
   admission. The Electrical Engineering Graduate Studies Committee may
suggest or require a list of undergraduate courses to make up the deficiencies in the undergraduate electrical engineering curriculum before unconditional admission to the graduate program may be granted. If such courses are listed as deficiencies, they will not count toward the graduate degree.

b) A minimum GPA of 2.75 or better in the last 60 hours and a GRE minimum of 1100 total verbal and quantitative portions may result in conditional admission. Students must take a list of undergraduate courses as specified by the Electrical Engineering Graduate Studies Committee to make up deficiencies in the undergraduate electrical engineering curriculum and maintain a 3.0 or better. If such courses are listed as deficiencies, they will not count toward the graduate degree. Upon satisfactory completion of these courses, unconditional admission to the graduate program may be granted.

Applicants with an electrical engineering background who wish to continue their education, but who do not intend to pursue the M.S.E.E. degree, are encouraged to seek admission as special graduate students.

Degree Requirements. The degree requirements for different options are as follows:

A. The following five core courses form the basis for the M.S. program in Electrical Engineering:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 5123</td>
<td>Digital Systems</td>
</tr>
<tr>
<td>EE 5143</td>
<td>Linear Systems and Control</td>
</tr>
<tr>
<td>EE 5153</td>
<td>Random Signals and Noise</td>
</tr>
<tr>
<td>EE 5163</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>EE 5183</td>
<td>Foundations of Communication Theory</td>
</tr>
</tbody>
</table>

B. The requirements for each option, with minimum semester-credit-hour requirements and their distribution, are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thesis Option:</strong></td>
<td></td>
</tr>
<tr>
<td>Core Courses (any three)</td>
<td>9</td>
</tr>
<tr>
<td>Additional graduate electrical engineering courses*</td>
<td>9</td>
</tr>
<tr>
<td>Courses from outside electrical engineering*</td>
<td>6</td>
</tr>
<tr>
<td>EE 6983 Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>EE 5991 Graduate Seminar</td>
<td>2</td>
</tr>
<tr>
<td><strong>Minimum Total Semester Credit Hours Required</strong></td>
<td>32</td>
</tr>
<tr>
<td><strong>Nonthesis Option:</strong></td>
<td></td>
</tr>
<tr>
<td>Core courses (any four)</td>
<td>12</td>
</tr>
<tr>
<td>Additional graduate electrical engineering courses*</td>
<td>15</td>
</tr>
<tr>
<td>Courses from outside electrical engineering*</td>
<td>6</td>
</tr>
<tr>
<td>EE 5991 Graduate Seminar</td>
<td>2</td>
</tr>
<tr>
<td><strong>Minimum Total Semester Credit Hours Required</strong></td>
<td>35</td>
</tr>
</tbody>
</table>

*Chosen with approval of the Electrical Engineering Graduate Studies Committee.
All degree plans must be consistent with the guidelines established by the Electrical Engineering Graduate Studies Committee. In addition to other University-wide requirements for the master's degree, all candidates are required to pass a comprehensive examination and/or a thesis defense administered by the student's advisory committee, chaired by a tenured or tenure-track graduate faculty member.

### COURSE DESCRIPTIONS

**ELECTRICAL ENGINEERING (EE)**

5123 **Digital Systems**
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor. Description of digital computer systems, arithmetic algorithms, central processor design, memory hierarchies and virtual memory, control unit and microprogramming, input and output, coprocessors, and multiprocessing.

5143 **Linear Systems and Control**
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor. Advanced methods of analysis and synthesis of linear systems, continuous and discrete-time systems, analytical approach to linear control theory.

5153 **Random Signals and Noise**
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor. Study of probability theory, random processes, mean and autocorrelation, stationarity and ergodicity, Gaussian and Markov processes, power spectral density, noise, and linear systems.

5163 **Digital Signal Processing**
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor. Study of discrete-time signals and systems, including Z-transforms, fast Fourier transforms, and digital filter theory. Filter design and effects of finite register length, and applications to one-dimensional signals.

5183 **Foundations of Communication Theory**
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor; EE 5153 suggested. Basis functions, orthogonalization of signals, vector representation of signals, optimal detection in noise, matched filters, pulse shaping, intersymbol interference, maximum likelihood detection, channel cutoff rates, error probabilities, bandwidth, and power-limited signaling.

5213 **Topics in Instrumentation**
(2-3) 3 hours credit. Prerequisites: EE 4453 or an equivalent, and EE 5153. Topics may include:
- Topic 2: Automatic Test Equipment. Techniques and standards for ATE; VXIbus, IEEE-488, and SCPI.

UTSA 1997–99 Graduate Catalog
Topic 3: Virtual Instruments. Implementation of VI as collection of instrumentation resources.
Topic 4: Silicon Instruments. Techniques for fabricating sensors and signal processing elements into integrated systems.
May be repeated for credit as topics vary.

5223  
Topics in Digital Design  
(3-0) 3 hours credit. Prerequisites: EE 5123 or consent of instructor. 
Topics may include:  
Topic 1: Switching Theory. Minimization of switching functions, synchronous and asynchronous sequential machines, minimization, reliable design, static hazards, fault detection and location.
Topic 3: RISC Processor Design. RISC concept, RISC versus CIOSC, RISC advantages and disadvantages, various processors survey, applications. Study of software development tools: assemblers, compilers, simulators, RISC implementations.
Topic 4: Microcomputer-Based Systems. 8- and 16-bit microprocessors, bus timing analysis, interfacing principles, LSI, VLSI chip interfacing. Use of software development tools such as assemblers, compilers, and simulators, and hardware development tools including logic analyzer. May be repeated for credit as topics vary.

5243  
Topics in Control Systems  
(3-0) 3 hours credit. Prerequisite: EE 5143.  
Topics may include:  
Topic 2: Multivariable Control Systems. Analysis and design of multivariable feedback systems, stability, performance, and robustness. Techniques may include LQG, Youla parameterization, and Nyquist-like methods.
Topic 3: Optimal Control. Optimal and suboptimal techniques for controller design using the principle of optimality, min-max principles, and induced norm minimization.
Topic 4: Nonlinear Control Systems. Nonlinear systems modeling and control, state-plane analysis, nonlinear stability analysis in time and frequency domains, Lyapunov stability, advanced nonlinear techniques. May be repeated for credit as topics vary.

5263  
Topics in Digital Signal Processing and Digital Filtering  
(3-0) 3 hours credit. Prerequisite: EE 5163 or consent of instructor.  
Topics may include:  
Topic 1: Nonlinear filters. Order statistic filters, morphological filters, stack/Boolean filters, and other related topics.

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Topic 3: Applications of DSP. Remote sensing, biomedical image analysis, underwater acoustics, video compression and processing, and analysis of biological signals.
Topic 4: Computer Vision. Image perception, parallel and sequential edge detection in the visual system, shape from shading, stereo vision, image segmentation by textural perception in humans, chain codes, B-splines, 3-D representations.
May be repeated for credit as topics vary.

5283 Topics in Communication Systems
(3-0) 3 hours credit. Prerequisite: EE 5183.
Topics may include:
Topic 1: Mobile Communications. Multipath-fading channels, diversity reception, the rake receiver, coding for fading channels, cellular networks, traffic capacities, multiaccessing schemes, spread spectrum signaling and code division multiple access, correlation receivers, and multiuser receiver methods.
Topic 3: Algebraic Coding Theory. Groups and fields, linear codes, Hamming distance, cyclic codes, minimum distance bounds, BACH codes and algebraic decoding, Reed Solomon (R) codes, Reed-Muller codes and maximum likelihood decoding, suboptimal decoding, and applications of coding.
Topic 4: Probabilistic Coding Theory. Channel capacity, convolutional codes (CC), coding and decoding of CCs, structure of CCs, distance and performance bounds, trellis coded modulation, suboptimum receivers, and advanced topics.
May be repeated for credit as topics vary.

5323 VLSI Design
(3-0) 3 hours credit. Prerequisite: EE 5123 or consent of instructor. Analysis and design of integrated devices such as Diode, BJT, and MOSFET. Design of LSI and VLSI digital and analog systems incorporating low-level devices and standard libraries. Trade-offs of various fabrication processes. Design automation and verification. Design and verification using VLSI system design tools such as OCTTOOLs, MAGIC, and SPICE.

5343 Intelligent Control and Robotics
(3-0) 3 hours credit. Prerequisite: EE 5143. Study of artificial neural networks control, knowledge-based control, and fuzzy logic control. Analytical techniques and fundamental principles of robotics; dynamics of robot arms, motion control, robot sensing, and robot intelligence.
5363 Digital Image Processing
(3-0) 3 hours credit. Prerequisite: EE 5163 or consent of instructor.
Study of binary image processing, histogram and point operations, algebraic
and geometric image operations, 2-D digital Fourier transform, convolution,
linear and nonlinear filtering, morphological filters, image enhancement,
linear image restoration (deconvolution), digital image coding and
compression, and Digital Image Analysis.

5383 Digital Information Theory
(3-0) 3 hours credit. Prerequisite: EE 5183.
Entropy and mutual information, Huffman coding, Tunstall coding,
Shannon's source coding theorem, channel coding theorems, channel
capacity, block coding error bounds, random coding bounds, cutoff rate,
multiuser information theory, random access channels and protocols,
multiaccess coding methods.

5423 Computer Arithmetics
(3-0) 3 hours credit. Prerequisite: Graduate standing or consent of instructor.
Fundamental principles of algorithms for performing arithmetic operations
in digital computers. Number systems, fast implementations of arithmetic
operations and elementary functions. Design of arithmetic units using CAD
tools.

5443 Discrete-Time Control Theory and Design
(3-0) 3 hours credit. Prerequisite: EE 5143.
Control theory relevant to deterministic and stochastic analysis and design
of computer-controlled systems using both state-space and input-output
models.

5463 Artificial Neural Networks
(3-0) 3 hours credit. Prerequisite: EE 5163 or consent of instructor.
Study of parallel optimization algorithms using Hopfield networks,
perceptrons, backpropagation competitive systems, and other unsupervised
techniques.

5483 Probabilistic Coding Theory
(3-0) 3 hours credit. Prerequisite: EE 5183.
Groups and rings, convolutional codes, probabilistic maximum-likelihood
decoding, bandwidth efficient coding, trellis coded modulation (TCM),
lattices and coset codes, trellis decoding of block codes, intersymbol
interference channels, and reduced-complexity decoding.

5991 Graduate Seminar
(1-0) 1 hour credit. Prerequisites: Graduate standing and consent of
instructor.
May be repeated for credit up to a limit of 2 hours.

6323 Advanced Topics in Computers
(3-0) 3 hours credit. Consent of Graduate Advisor of Record and Dissertation
Director.
Current topics in the computer area. May be repeated for credit as topics vary.
6343 Advanced Topics in Control
(3-0) 3 hours credit. Consent of Graduate Advisor of Record and Dissertation Director.
Current topics in the control area. May be repeated for credit as topics vary.

6363 Advanced Topics in Signal Processing
(3-0) 3 hours credit. Consent of Graduate Advisor of Record and Dissertation Director.
Current topics in the signal processing area. May be repeated for credit as topics vary.

6383 Advanced Topics in Communications
(3-0) 3 hours credit. Consent of Graduate Advisor of Record and Dissertation Director.
Current topics in the communications area. May be repeated for credit as topics vary.

6951-3 Independent Study
1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6961 Comprehensive Examination
1 hour credit. Prerequisite: Approval of the Electrical Engineering Graduate Studies Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated for credit as many times as approved by the Electrical Engineering Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

6971-3 Special Problems
(1-0 to 3-0) 1 to 3 hours credit. Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, may be applied to the master's degree.

6983 Master’s Thesis
3 hours credit. Prerequisite: Consent of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.
Master of Science Degree in Mechanical Engineering

The Master of Science program in Mechanical Engineering is designed to offer students the opportunity to prepare for leadership roles in careers with industry, government, or educational institutions. A thesis option is offered for those students who desire the opportunity to obtain some expertise in research. A nonthesis option is also available for those students who desire a practical industrial applications-oriented degree.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, applicants must meet the following additional admission requirements:

1. A satisfactory score, as specified by the Graduate Studies Committee for Mechanical Engineering, on the GRE general aptitude test.
2. A bachelor's degree in mechanical engineering or a bachelor's degree in a science or other engineering discipline from an accredited institution of higher education. Applicants with a degree in a discipline other than mechanical engineering may be required to make up the deficiencies in the undergraduate mechanical engineering curriculum before unconditional admission to the graduate program will be granted. If such courses are listed as deficiencies, they will not count toward the graduate degree.
3. Letters of recommendation from former instructors of supervisors of employment may be requested by the Mechanical Engineering Graduate Studies Committee.

Degree Requirements. Graduate students are expected to maintain a cumulative GPA of 3.0 in the approved program of study. Students must also pass a comprehensive examination administered by the student’s advisory committee, chaired by a full-time graduate faculty member or cochaired by both a full-time and adjunct graduate faculty member. Candidates for this degree are required to successfully complete either a thesis or a nonthesis degree. The requirements for each of these options with minimum semester-credit-hour requirements and their distributions are as follows:

Thesis Option:

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated electives (approved in consultation with chairman of student's advisory committee)</td>
<td>15</td>
</tr>
<tr>
<td>Free electives chosen from graduate engineering courses</td>
<td>9</td>
</tr>
<tr>
<td>Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>Minimum Total Semester Credit Hours Required</td>
<td>30</td>
</tr>
</tbody>
</table>

Nonthesis Option:

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated electives (approved in consultation with chairman of student's advisory committee)</td>
<td>21</td>
</tr>
<tr>
<td>Free electives chosen from graduate engineering courses</td>
<td>9</td>
</tr>
<tr>
<td>ME 5973: Special Project</td>
<td>3</td>
</tr>
<tr>
<td>Minimum Total Semester Credit Hours Required</td>
<td>33</td>
</tr>
</tbody>
</table>
COURSE DESCRIPTIONS
MECHANICAL ENGINEERING
(ME)

5123  Topics in Mechanical Engineering
(3-0) 3 hours credit.
Topics may include reliability and quality control, maintenance, and material
issues. May be repeated for credit as topics vary.

5223  Topics in Dynamics
(3-0) 3 hours credit. Prerequisites: ME 3323 or an equivalent, and MAT
3263 or an equivalent.
Topic 1: Advance Dynamics. Analytical dynamics, including Newton-Euler,
Lagrange, and Hamilton's principles; gyroscopic effects; stability.
Topic 2: Structural Dynamics. Matrix methods for analysis of dynamics of
complex structures, computer solutions, system identification, and
experimental modal analysis.
Topic 3: Dynamics of Rotating Machinery. Dynamic stability, critical speeds,
and unbalanced response of rotor-bearing systems; operation through and
above critical speeds.
Topic 4: Nonlinear Systems and Chaos. Phase space representation, local
and global stability, time and frequency domain characterization,
applications to oscillatory systems in various engineering disciplines.
May be repeated for credit as topics vary.

5233  Topics in Advanced Thermodynamics
(3-0) 3 hours credit. Prerequisite: Graduate standing.
Topic 1: Advanced Thermodynamics. Concepts and postulates of
macroscopic thermodynamics; formulation or thermodynamic principles;
stability of thermodynamic systems.
Topic 2: Thermodynamics of Materials. Phase equilibria, solutions, phase
rule, phase diagrams, defects in solids, surfaces and interfaces, diffusions,
and transformations.
May be repeated for credit as topics vary.

5313  Topics in Heat Transfer
(3-0) 3 hours credit. Prerequisite: ME 4313 or an equivalent.
Topic 1: Conduction. Derivation of governing equations, steady and transient
solutions, variable property effects, numerical methods.
Topic 2: Convection. Derivation of equations of convection of mass,
momentum and energy; boundary layer solutions; classical laminar
convection problems; turbulent convection.
Topic 3: Radiation. Thermal radiation laws; geometric factors; black bodies;
gray enclosures; non-gray systems; combined conduction, convection, and
radiation.
May be repeated for credit as topics vary.
5413  **Topics in Mechanical Vibrations**  
(3-0) 3 hours credit. Prerequisites: ME 4513 or an equivalent, and MAT 3263 or an equivalent.

Topic 1: Mechanical Vibrations. Dynamics of high-order lumped-component systems, modal testing, system identification, design and control; approximate methods.

Topic 2: Nonlinear Vibrations. Classic methods in nonlinear analysis; modern techniques for analysis of deterministic and chaotic behavior.

Topic 3: Random Vibrations. Randomly excited mechanical systems and structures; stationary and ergodic processes; first passage and fatigue failures; data analysis techniques.

May be repeated for credit as topics vary.

5523  **Topics in Mechanical Design**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in Engineering.

Topic 1: Advanced Mechanism Design. Advanced topics in kinematic synthesis of linkages, static and dynamic force analyses, and computer-aided design of mechanisms.

Topic 2: Advanced Machine Design. Advanced problems in design, including bearings, brakes and clutches, gears, shafts, springs; advanced stress analysis.


Topic 4: Advanced Design of Cams and Gears. Advanced problems in design of cam follower systems; spur, helical, bevel, and worm gears, and gear trains.

May be repeated for credit as topics vary.

5663  **Topics in Fluid Dynamics**  
(3-0) 3 hours credit. Prerequisite: ME 3663 or an equivalent.

Topic 1: Incompressible Fluid Mechanics. Dynamics of incompressible and compressible fluids; viscous flow; Navier-Stokes equations; boundary layer theory; applications to machinery design.

Topic 2: Two-Phase Flow. Basic treatment of two-phase flow; detailed analysis of flow of suspended particles, bubbles, mists; analysis of slug and annular flows; measurement techniques.

Topic 3: Gas Dynamics. Integral and differential forms of the conservation equations, one-dimensional flow, oblique shock and expansion waves, and supersonic, transonic, and hypersonic flows.


Topic 5: Computational Fluid Dynamics. The mathematical models for fluid flow simulations at various levels of approximation, basic description techniques, nature of the flow equations and their boundary conditions.

May be repeated for credit as topics vary.
**5973 Special Project**
3 hours credit. Prerequisite: Permission in writing (form available) from the instructor and the student's graduate advisor of record.
The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

**5991 Graduate Seminar**
(1-0) 1 hour credit. Prerequisites: Graduate standing and consent of instructor.
May be repeated for credit up to a limit of 2 hours.

**6951-3 Independent Study**
1 to 3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record.
Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

**6961 Comprehensive Examination**
1 hour credit. Prerequisite: Approval of the Mechanical Engineering Graduate Studies Committee to take the Comprehensive Examination.
Independent study for the purpose of taking the Comprehensive Examination. May be repeated for credit as many times as approved by the Mechanical Engineering Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

**6971-3 Special Problems**
(1-0 to 3-0) 1 to 3 hours credit. Prerequisite: Consent of instructor.
An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, may be applied to the master's degree.

**6983 Master's Thesis**
3 hours credit. Prerequisite: Consent of the Graduate Advisor of Record and thesis director.
Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.
DIVISION OF LIFE SCIENCES

Master of Science Degree in Biology

The graduate program offers opportunities for advanced study and research leading to the Master of Science degree in Biology. A thesis option is offered to students desiring an opportunity to develop expertise in research techniques and data analysis; a nonthesis option is offered for those who desire the opportunity to earn the M.S. degree primarily through organized coursework. The thesis option is recommended for students who are planning a career in research or who contemplate pursuing a doctorate in one of the life sciences. The nonthesis option might be suitable for students interested in secondary school teaching in the life sciences.

Graduate faculty research interests include biochemistry, cellular biology, developmental biology, ecology, genetics, microbiology, neurobiology, physiology, and plant sciences. The multidisciplinary nature of the program also allows students the opportunity to broaden their educational background at the graduate level. Individual programs are organized around each student's interests in consultation with the student's graduate advisor.

Qualified students are encouraged to apply for teaching assistantships and fellowships. Requests should be sent to the Director of the Division of Life Sciences at the same time application is made for admission to UTSA.

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, applicants are expected to have completed an undergraduate major in one of the biological sciences, with coursework comparable to that required for the B.S. in Biology at UTSA. Students whose undergraduate preparation is deficient in certain areas, but who meet the minimum University standards for admission, may be conditionally admitted and required to complete specific undergraduate or graduate courses as conditions of admission. In such cases, students should anticipate that additional time will be required to complete the degree. In order to be considered for degree-seeking status, all applicants must submit two letters of recommendation directed to the Chairperson of the Graduate Studies Committee, Division of Life Sciences. In addition, in order to be considered for degree-seeking status, all applicants must submit scores from the Graduate Record Examination with their application.

Degree Requirements. All candidates for the degree are required to complete a minimum of 36 semester credit hours approved by the student's graduate advisor of record. These 36 hours will be subject to the following conditions:

1. A minimum of 18 semester hours of graduate credit in organized classes must be earned within the division. This total may include up to 6 semester credit hours of approved upper-division undergraduate coursework, and a maximum of 3 semester credit hours earned in a graduate seminar (BIO 7051).
2. An additional 18 semester hours of graduate credit as approved by the Graduate Advisor of Record. This total may include a maximum of 6 hours of BIO 5973: Directed Research. For students electing the nonthesis option, a minimum of 3
semester credit hours of BIO 5973: Directed Research must be included. Students
electing the thesis option must complete 6 semester credit hours of BIO 6983:
Master’s Thesis as part of this total.

Comprehensive Examination. As specified by University regulations, all students
must pass a comprehensive examination administered by their graduate committee.
This exam is normally given in the semester prior to the semester during which
degree requirements are to be completed. Certain rules must be adhered to concerning
the composition of the Master’s Thesis Committee and the Master’s Comprehensive
Examination Committee. Only tenured or tenure-track faculty members can chair
master’s thesis committees and master’s comprehensive examination committees.
No more than one member of the Master’s Thesis Committee or the Master’s
Comprehensive Examination Committee can be a nontenured or nontenure-track
faculty member, or be from another university. Students electing the thesis option
also must successfully defend their thesis research before their graduate committee
prior to the submission of the thesis to the Provost and Vice President for Academic
Affairs for approval.

Master of Science Degree in Biotechnology

The Master of Science degree in Biotechnology offers opportunities for advanced
study and research related to the rapidly developing fields of applied biology. A broad
common base of knowledge for biotechnology is provided in the M.S. degree by a
comprehensive core curriculum that encompasses key areas in biology, computer
science, and statistics. Additional coursework for the degree is selected from one of
four concentrations from which specialized courses may be chosen. These
concentrations are (1) Molecular Neurobiology, (2) Quantitative Biology, (3)
Bioprocessing Technology, and (4) Molecular Toxicology. The opportunity to develop
additional technical expertise is also available through directed research.

Program Admission Requirements. In addition to satisfying the University-wide
graduate requirements, applicants are expected to have completed an undergraduate
major in the sciences with coursework comparable to the core required for the B.S. in
Biology at UTSA. Students must also have completed courses equivalent to BIO
3713, 3722: Microbiology and Laboratory and CS 1073: Introductory Computer
Programming for Scientific Applications. Students electing the concentration in
Quantitative Biology must have had a course equivalent to MAT 1214: Calculus I.
Students whose undergraduate preparation is deficient in certain areas, but who meet
the minimum University standards for admission, may be conditionally admitted
and required to complete specific undergraduate or graduate courses as conditions of
admission. If such courses are listed as deficiencies, they will not count toward the
graduate degree for the student. In such cases, students should anticipate that additional
time will be required to complete the degree. In order to be considered for degree-
seeking status, all applicants must submit two letters of recommendation directed to
the Chairperson of the Graduate Studies Committee for the M.S. in Biotechnology,
Division of Life Sciences. In addition, to be considered for degree-seeking status, all
applicants must submit scores from the Graduate Record Examination with their
application.

UTSA 1997–99 Graduate Catalog
A. Biotechnology core curriculum (18 semester credit hours):

BIO 5353 Molecular and Biochemical Genetics
BIO 6803 Advanced Immunology and Immunochemistry
BIO 7051 Seminar in Life Sciences (must be repeated three times)
BIO 7513 Advanced Biochemistry
BIO 7643 Cellular and Molecular Biology
STA 5073 Methods of Statistics I

B. Biotechnology electives (18 semester credit hours):

Each student must complete 18 semester credit hours of biotechnology electives, at least 9 hours of which must be selected from a single concentration as shown below:

Concentration 1: Molecular Neurobiology

BIO 5423 Neuroanatomy
BIO 5433 Neurophysiology
BIO 5443 Neurochemistry
BIO 5523 Enzymes
BIO 5563 Biochemical Macromolecules
BIO 5833 Membrane Structure and Function
BIO 7571-3 Experimental Techniques in the Life Sciences

Concentration 2: Quantitative Biology
(Note: The courses in computer science listed below have specific prerequisites, which students must meet before enrolling.)

CS 5103 Software Engineering
CS 5233 Artificial Intelligence
CS 6133 Software Specification and Verification
STA 5083 Methods of Statistics II

Concentration 3: Bioprocessing Technology

BIO 5363 Microbial Genetics
BIO 5523 Enzymes
BIO 5563 Biochemical Macromolecules
BIO 6553 Fermentation Science
BIO 6563 Food Science and Technology
BIO 6873 Microbial Physiology and Energetics
BIO 7571-3 Experimental Techniques in the Life Sciences—Monoclonal Antibodies and Flow Cytometry
BIO 7571-3 Experimental Techniques in the Life Sciences—Recombinant DNA
BIO 7571-3 Experimental Techniques in the Life Sciences—Tissue Culture and Somatic Cell Genetics
Concentration 4: Molecular Toxicology

<table>
<thead>
<tr>
<th>BIO</th>
<th>5423</th>
<th>Neuroanatomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO</td>
<td>5443</td>
<td>Neurochemistry</td>
</tr>
<tr>
<td>BIO</td>
<td>5543</td>
<td>Pharmacology and Toxicology</td>
</tr>
<tr>
<td>BIO</td>
<td>6483</td>
<td>Animal Behavior</td>
</tr>
</tbody>
</table>

C. Directed Research

Students may elect to develop expertise in research techniques in a selected emphasis on biotechnology through BIO 5973: Directed Research

Comprehensive Examination. As specified by University regulations, all students must pass a comprehensive examination administered by their graduate committee. This exam is normally given in the semester prior to the semester during which degree requirements are to be completed. Certain rules must be adhered to concerning the composition of the Master's Thesis Committee and the Master's Comprehensive Examination Committee. Only tenured or tenure-track faculty members can chair master's thesis committees and master's comprehensive examination committees. No more than one member of the Master's Thesis Committee or the Master's Comprehensive Examination Committee can be a nontenured or nontenure-track faculty member, or be from another university. This regulation ensures that tenured and tenure-track faculty must take the responsibility for the training and testing of the master's candidates in biology. This examination will normally be given in the semester prior to the semester during which the degree requirements are to be completed.

Doctor of Philosophy Degree in Biology

The Division of Life Sciences offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Biology. The degree program is currently organized with an emphasis in molecular and cellular neurobiology. The Ph.D. in Biology is awarded to candidates who have 1) displayed an in-depth understanding of the subject matter and 2) demonstrated the ability to make an original contribution to knowledge in their field of specialty.

The regulations for this degree comply with the general University regulations (refer to chapters 5, General Academic Regulations, and 7, Doctoral Degree Regulations).

Admission Requirements. All prospective students must have a B.A. or a B.S. degree from an accredited university and a minimum GPA of 3.0 in upper-division and graduate work, preferably in biology. Entering students should have a GRE (analytical and verbal) score of no less than 1000. Exceptions can be made in cases with a strong justification (e.g., high GPA and/or extensive research experience). Applicants whose native language is not English must score at least 550 on the TOEFL. The Doctoral Studies Committee, comprised of members selected from the graduate faculty, will be responsible for advising students. Admission requires appointment to a teaching assistantship, research assistantship, or research fellowship.
Degree Requirements. The doctoral degree requires a minimum of 90 semester credit hours beyond the baccalaureate degree. The core curriculum consists of 1) 30 semester credit hours of formal coursework, including elective courses that support the emphasis in neurobiology, and 2) required teaching, research, and completion of the dissertation following advancement to candidacy. Enrollment in the Life Sciences Colloquium and Seminar in Life Sciences are required each semester of enrollment and may be taken for a maximum combined total of 27 semester credit hours. A minimum of 36 semester credit hours in doctoral research, including 12 hours for the doctoral dissertation, must be completed. Any grade lower than “B” in a graduate course or in remediating coursework at the undergraduate level will not count toward the 90 hours. Students matriculating with a master’s degree may receive up to 30 semester credit hours provided the courses are comparable to core and elective courses.

Program of Study

A. Core Curriculum (15 semester credit hours required):

- **BIO 7113** Supervised Teaching in Life Sciences
- **BIO 7513** Advanced Biochemistry
- **BIO 7573** Experimental Techniques in the Life Sciences
  - Quantitative Biology: 3 hours
  - Research Rotations: 3 hours
- **BIO 7643** Cellular and Molecular Biology
  - 6 hours

B. Colloquia and Seminars (27 semester credit hours maximum):

- **BIO 7041** Life Sciences Colloquium
- **BIO 7051** Seminar in Life Sciences

C. Doctoral Research (36 semester credit hours minimum):

- **BIO 7211-3** Doctoral Research (24 hours minimum)
- **BIO 7311-3** Doctoral Dissertation (12 hours minimum)

D. Electives (15 semester credit hours minimum):

- **BIO 5423** Neuroanatomy
- **BIO 5433** Neurophysiology
- **BIO 5443** Neurochemistry
- **BIO 5453** Neuroendocrinology
- **BIO 5503** Sensory Physiology
- **BIO 5543** Pharmacology and Toxicology
- **BIO 5833** Membrane Structure and Function
- **BIO 6803** Advanced Immunology and Immunochemistry
  - 3 hours

The entire program of study must be approved by the student’s dissertation advisor, dissertation committee, and doctoral studies committee and must be submitted to the Associate Vice President for Graduate Studies and Research through the Dean of the College for final approval.
Advancement to Candidacy. Advancement to candidacy requires a student to complete all University and program requirements and to pass written and oral qualifying examinations within one year following completion of all course requirements. The written examination will be constructed, administered, and evaluated by the Doctoral Studies Committee. The oral examination will be conducted by a faculty committee nominated by the Doctoral Studies Committee and approved by the Dean of the College and the Associate Vice President for Graduate Studies and Research. No more than two attempts to pass qualifying examinations will be allowed. Results of the written and oral examinations must be reported to the Associate Vice President for Graduate Studies and Research through the Dean of the College. Admission into the Ph.D. program does not guarantee advancement to candidacy.

Dissertation. Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The research topic will be determined by the student in consultation with his or her supervising professor. A dissertation committee selected by the student and supervising professor and approved by the Dean of the College and the Associate Vice President for Graduate Studies and Research will guide and critique the candidate's research. The Dissertation Committee must approve the completed dissertation.

Final Oral Examination. Following an open presentation of the dissertation findings, the Dissertation Committee will conduct a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Associate Vice President for Graduate Studies and Research through the Dean of the College. The awarding of the degree is based upon the approval of the Dissertation Committee, selected and approved by the Dean and Associate Vice President for Graduate Studies and Research. The Associate Vice President for Graduate Studies and Research will certify the completion of all University-wide requirements.

COURSE DESCRIPTIONS

BIOLOGY
(BIO)

5263 Microbial Ecology
(3-0) 3 hours credit. Prerequisite: BIO 3713 or consent of instructor. Interrelationships between microorganisms and their environment, including natural habitats of microorganisms, normal human flora, and pathogens. Special consideration will be given to application of genetically engineering microorganisms for environmental problems.

5313 Cytogenetics
(3-0) 3 hours credit. Prerequisite: BIO 2313 or an equivalent. An analysis of chromosome structure and function, gene location, crossing-over, and variations in chromosome structure and number.
5333 Advanced Population Genetics  
(3-0) 3 hours credit. Prerequisites: BIO 2313 and BIO 2322, or their equivalents. Biostatistics highly recommended. An experimental approach to the interaction of genotype and environment in populations, with emphasis on mutagenesis, selection, polymorphism, and adaptive mechanisms.

5353 Molecular and Biochemical Genetics  
(3-0) 3 hours credit. Prerequisites: BIO 2313 and BIO 3513, or their equivalents. Molecular and biochemical aspects of structure, replication, mutation, and phenotypic expression of genetic material.

5363 Microbial Genetics  
(3-0) 3 hours credit. Prerequisites: BIO 2313 and BIO 3713, or their equivalents. A study of bacterial, fungal, and viral genetics. Emphasis on the current literature, data interpretation, and experimental techniques.

5403 Advanced Comparative Animal Physiology  
(3-0) 3 hours credit. Prerequisite: BIO 4353 or an equivalent. Physiology of the organs and organ systems of animals.

5423 Neuroanatomy  
(3-0) 3 hours credit. Prerequisite: Consent of instructor. The anatomy of the vertebrate nervous system.

5433 Neurophysiology  
(3-0) 3 hours credit. Prerequisite: BIO 4353 or an equivalent. Physiology of the nervous system. Emphasis on sensory and motor systems and neural correlations of behavior.

5443 Neurochemistry  
(3-0) 3 hours credit. Prerequisites: BIO 3513, 3522, and 4433. An examination of basic biochemical phenomena involved in normal neural processes and some pathological changes associated with neurobiological diseases and disorders.

5453 Neuroendocrinology  
(3-0) 3 hours credit. Prerequisites: BIO 3813 and 4433. Anatomical and molecular neurobiology of the endocrine hypothalamus and associated organs. Morphological, cell biological, and feedback mechanisms of endocrine regulation are emphasized.

5463 Reproductive Biology  
(3-0) 3 hours credit. Prerequisites: Courses in organ physiology and endocrinology or consent of instructor. A comparative study of mammalian reproduction with emphasis on vertebrate/mammalian reproduction, including cellular and systems mechanisms, hormonal regulation, and the effects of environmental factors.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5503</td>
<td>Sensory Physiology</td>
<td>(3-0)</td>
<td>BID 4433 or consent of instructor.</td>
<td>Principles of sensory physiology, including sensory transduction and central processing of sensory information in vertebrate and invertebrate species.</td>
</tr>
<tr>
<td>5523</td>
<td>Enzymes</td>
<td>(3-0)</td>
<td>BID 3513 or an equivalent.</td>
<td>A study of enzyme structure and mechanism, inhibitors, cofactor, kinetics, and regulation.</td>
</tr>
<tr>
<td>5543</td>
<td>Pharmacology and Toxicology</td>
<td>(3-0)</td>
<td>BID 3513, 3522, 3413, and 3422.</td>
<td>A review of the beneficial, adverse, and toxic reactions of individuals to a variety of drugs and environmental substances. Chemical, biochemical, pharmacological, toxicological, genetic, teratogenic, and pathological aspects will be examined.</td>
</tr>
<tr>
<td>5563</td>
<td>Biochemical Macromolecules</td>
<td>(3-0)</td>
<td>BID 3513 or an equivalent.</td>
<td>Structure, function, and isolation of macromolecules. Emphasis is on nucleic acids and proteins and their interactions.</td>
</tr>
<tr>
<td>5633</td>
<td>Cytodifferentiation</td>
<td>(3-0)</td>
<td>Graduate standing in the life sciences.</td>
<td>Detailed study of selected areas of developmental biology relating to cellular differentiation, including nuclear-cytoplasmic interactions, induction, and reversibility of differentiation.</td>
</tr>
<tr>
<td>5743</td>
<td>Biochemical Virology</td>
<td>(3-0)</td>
<td>Graduate standing in the life sciences.</td>
<td>A detailed study of the diversity of viruses and biochemical mechanisms for their replication.</td>
</tr>
<tr>
<td>5833</td>
<td>Membrane Structure and Function</td>
<td>(3-0)</td>
<td>BID 3513 or an equivalent.</td>
<td>A study of the composition, organization, transport functions, and permeability of natural and model membranes.</td>
</tr>
<tr>
<td>5971-3</td>
<td>Directed Research</td>
<td>1-3</td>
<td>Graduate standing and permission in writing (form available) of the instructor and the student’s graduate advisor of record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master’s degree.</td>
<td></td>
</tr>
<tr>
<td>6113</td>
<td>Advanced Plant Physiology</td>
<td>(3-0)</td>
<td>BID 4603 or consent of instructor.</td>
<td>Principles of plant physiology and biochemistry, with particular emphasis on plant hormones, nitrogen fixation, plant respiration, photosynthesis, and current research work.</td>
</tr>
</tbody>
</table>
6133 Methods in Field Biology
(3-0) 3 hours credit. Prerequisite: BIO 3283 or an equivalent.
Examination of techniques to collect, identify, and preserve plants and
animals. Field methods used in the analysis of populations and communities
will be considered.

6213 Advanced Ecology
(3-0) 3 hours credit. Prerequisite: BIO 3283 or an equivalent.
Interaction of organisms with their environment, allelopathy, competition,
distribution, succession, and factors that control growth and dispersal.
Special consideration will be given to the concepts of climax, succession,
and land management.

6373 Invertebrate Physiology
(3-0) 3 hours credit. Prerequisite: BIO 3413.
An investigation of the mechanisms of respiration, movement, ion and
water regulation, and hormonal integration in the invertebrates.

6483 Animal Behavior
(3-0) 3 hours credit. Prerequisite: BIO 3413 or consent of instructor.
An examination of neural, endocrine, genetic, and environmental
determinants of behavior.

6553 Fermentation Science
(3-0) 3 hours credit. Prerequisites: BIO 3713 and 3722, or their equivalents.
The principles and theory underlying industrial fermentations, such as vessel
design and construction, media design, upscaling fermentations, process
control, and product isolation.

6563 Food Science and Technology
(3-0) 3 hours credit. Prerequisites: BIO 3713 and 3722, or their equivalents.
The science underlying industrial processes related to foods. The latest
applications of technologies such as strain isolation and improvement, raw
material selection and storage, process monitoring, and the assessment of
chemical and microbiological status of products.

6663 Experimental Parasitology
(3-0) 3 hours credit. Prerequisite: A course in parasitology or consent of
instructor.
A study of animal parasites, with special emphasis on the physiology of
host-parasite interactions.

6773 Host-Parasite Interactions
(3-0) 3 hours credit. Prerequisite: BIO 3713 or consent of instructor.
A study of infectious disease processes, with emphasis on host-parasite
relationships of selected microbial pathogens.

6803 Advanced Immunology and Immunochemistry
(3-0) 3 hours credit. Prerequisite: BIO 4743 or consent of instructor.
The study of current concepts of humoral and cell-mediated immunity, with
emphasis on molecular mechanisms.
Molecular Radiation Biology
(3-0) 3 hours credit. Prerequisite: BIO 3513 or consent of instructor.
A study of biological effects of ionizing and nonionizing radiation, with
emphasis on repair mechanisms of radiation damage at the cellular and
subcellular level. Applications in cancer therapy will be included.

Microbial Physiology and Energetics
(3-0) 3 hours credit. Prerequisite: BIO 3713 or consent of instructor.
Consideration of physiological activities of microorganisms, with special
emphasis on metabolic capabilities of bacteria and other microorganisms.

Independent Study
1 to 3 hours credit. Prerequisites: Graduate standing and permission in
writing (form available) of the instructor and the student's graduate advisor
of record.
Independent reading, research, discussion, and/or writing under the
direction of a faculty member. For students needing specialized work not
normally or not often available as part of the regular course offerings. May
be repeated for credit, but not more than 6 hours, regardless of discipline,
will apply to the master's degree.

Comprehensive Examination
1 hour credit. Prerequisite: Approval of the appropriate graduate studies
committee to take the Comprehensive Examination.
Independent study course for the purpose of taking the Comprehensive
Examination. May be repeated as many times as approved by the Graduate
Studies Committee. Enrollment is required each term in which the
Comprehensive Examination is taken if no other courses are being taken
that term. The grade report for the course is either CR (satisfactory
performance on the Comprehensive Examination) or NC (unsatisfactory
performance on the Comprehensive Examination).

Special Problems
(3-0) 3 hours credit. Prerequisite: Consent of instructor.
An organized course offering the opportunity for specialized study not
normally or not often available as part of the regular course offerings. This
course may be repeated for credit when the topics vary, but not more than 6
hours, regardless of discipline, may be applied to the master's degree.

Master's Thesis
3 hours credit. Prerequisites: Permission of the Graduate Advisor and thesis
director.
Thesis research and preparation. May be repeated for credit, but not more
than 6 hours will apply to the master's degree. Credit will be awarded upon
completion of the thesis. Enrollment is required each term in which the
thesis is in progress.

UTSA 1997–99 Graduate Catalog
7041 Life Sciences Colloquium
(1-0) 1 hour credit. Prerequisite: Graduate standing.
Discussions of current journal articles, reviews, and recent advances in
specialized areas of the biological sciences. May be repeated for credit as
topics vary. The grade report for this course is either CR (satisfactory
participation in the colloquium) or NC (unsatisfactory participation in the
colloquium). (Formerly BIO 5041.)

7051 Seminar in Life Sciences
(1-0) 1 hour credit. Prerequisite: Graduate standing.
Formal presentations of research by outside authorities in the biological
sciences. May be repeated for credit. The grade report for this course is
either CR (satisfactory participation in the seminar) or NC (unsatisfactory
participation in the seminar).

7113 Supervised Teaching in Life Sciences
3 hours credit. Prerequisite: Admission to candidacy for the doctoral degree.
May be repeated for credit.

7211-3 Doctoral Research
1 to 3 hours credit. Prerequisite: Admission to candidacy for the doctoral
degree.
May be repeated for credit but no more than 24 hours may be applied to the
doctoral degree.

7311-3 Doctoral Dissertation
1 to 3 hours credit. Prerequisite: Admission to candidacy for the doctoral
degree and completion of at least 21 hours of BIO 7211-3.
May be repeated for credit, but no more than 12 hours may be applied to the
doctoral degree.

7513 Advanced Biochemistry
(3-0) 3 hours credit. Prerequisite: BIO 3513 or an equivalent.
An in-depth discussion of structure-function relationships in biological
systems, including bioenergetics of metabolism and hormonal and
nonhormonal regulation of metabolic pathways. (Formerly BIO 5513. Credit
cannot be earned for both BIO 7513 and BIO 5513.)

7571-3 Experimental Techniques in the Life Sciences
1 to 3 hours credit. Prerequisite: Consent of instructor.
Topics will include research methods in cell and molecular biology,
molecular neurobiology, and microbiology. (Formerly BIO 5571-3.) May
be repeated for credit as topics vary.

7643 Cellular and Molecular Biology
(3-0) 3 hours credit. Prerequisite: BIO 3513 or consent of instructor.
Structure of eucaryotic and procaryotic cells, functions of biomembranes
and cytoplasmic organelles, and regulation of cellular activity. (Formerly
BIO 6643. Credit cannot be earned for both BIO 7643 and BIO 6643.)
DIVISION OF MATHEMATICS AND STATISTICS

Master of Science Degree in Mathematics

The Master of Science degree in Mathematics is offered with three concentrations:

Concentration 1. Mathematics
Concentration 2. Mathematics Education
Concentration 3. Statistics

Program Admission Requirements. In addition to satisfying the University-wide graduate admission requirements, at least a B.A. or B.S. in Mathematics or Statistics or a closely related field is highly recommended as preparation. Those students who do not qualify for unconditional admission should anticipate that additional undergraduate and/or graduate coursework may be required to complete the degree. All applicants are required to submit scores from the Graduate Record Examination aptitude test (GRE).

Degree Requirements. Candidates for this degree are required to complete successfully 36 semester credit hours.

A. All candidates for the Master of Science in Mathematics, regardless of concentration, must complete the following 9 hours of coursework:

MAT 5203 Theory of Functions of a Real Variable I
MAT 5283 Linear Algebra and Matrix Theory
STA 5503 Mathematical Statistics I

B. In addition, a candidate for the Master of Science in Mathematics must complete the required courses for one of the concentrations declared by the candidate.

1. **Concentration in Mathematics (12 semester credit hours):**

   MAT 5173 Algebra I
   MAT 5223 Theory of Functions of a Complex Variable I
   MAT 5403 Functional Analysis I
   MAT 5603 Numerical Analysis

2. **Concentration in Mathematics Education (9 semester credit hours):**

   MAT 5023 Problem Solving Seminar
   MAT 5033 Foundations and Fundamental Concepts of Mathematics
   MAT 5043 Euclidean and Non-Euclidean Geometry

3. **Concentration in Statistics (9 semester credit hours):**

   STA 5413 Nonparametric Statistics
   STA 5513 Mathematical Statistics II
   STA 5713 Linear Models I
C. Each student in the master's program is required either to write a master's thesis or complete 6 semester credit hours of advanced courses in the division as approved by the Graduate Advisor of Record.

D. Students pursuing the concentration in Mathematics must normally take an additional 9 semester credit hours of coursework chosen from eligible graduate courses within the Division of Mathematics and Statistics. Students pursuing the concentration in Mathematics Education or concentration in Statistics must normally take an additional 12 semester credit hours of coursework chosen from eligible graduate courses within the Division of Mathematics and Statistics. However, a maximum of 6 semester credit hours of graduate work from other disciplines approved by the Graduate Advisor of Record may be applied toward these requirements. Students pursuing the concentration in Mathematics Education may apply a maximum of 9 semester credit hours of graduate coursework chosen from other disciplines as approved by the Graduate Advisor of Record.

E. Each candidate for the degree is required to pass an advanced comprehensive examination or successfully defend his or her thesis research results.

COURSE DESCRIPTIONS  
MATHEMATICS  
(MAT)

5003 Modern Mathematics for Teachers  
(3-0) 3 hours credit.  
A practical orientation concerned with the classroom uses of mathematics for teachers of K–12. May not be applied toward the Master of Science degree in Mathematics.

5013 Computers for Mathematics Teachers  
(3-0) 3 hours credit.  
A course for mathematics teachers on integrating the computer into the mathematics curriculum, with an algorhitmic-oriented introduction to computer programming in BASIC or Pascal and the extensive use of mathematical software packages such as Derive. This course can only be applied to graduate majors in mathematics with a concentration in Mathematics Education. (Same as CS 5023. Credit cannot be earned for both MAT 5013 and CS 5023.)

5023 Problem Solving Seminar  
(3-0) 3 hours credit.  
Students will have the opportunity to engage in extensive experience and practice in solving mathematical problems. This course can only be applied to majors in mathematics with a concentration in Mathematics Education.
Foundations and Fundamental Concepts of Mathematics
(3-0) 3 hours credit.
Topics include the study of mathematics in antiquity as an empirical science, the shift from inductive reasoning to axiomatic structures, the development of geometry in the plane and 3-space, the discovery of analysis, the emergence of axiomatic systems, and the focus on algebraic structures. This course can only be applied to majors in mathematics with a concentration in Mathematics Education.

Euclidean and Non-Euclidean Geometry
(3-0) 3 hours credit.
Topics will be selected from advanced euclidean and non-euclidean geometry, solid analytic geometry, and differential geometry. This course can only be applied to majors in mathematics with a concentration in Mathematics Education.

Algebra I
(3-0) 3 hours credit. Prerequisite: MAT 4233 or consent of instructor. The opportunity for development of basic theory of algebraic structures. Areas of study include finite groups, isomorphism, direct sums, polynomial rings, algebraic numbers, number fields, unique factorization domain, prime ideals, and Galois groups.

Theory of Functions of a Real Variable I
(3-0) 3 hours credit. Prerequisite: MAT 4223 or consent of instructor. Measure and integration theory.

Theory of Functions of a Real Variable II
(3-0) 3 hours credit. Prerequisite: MAT 5203. Further development of measure and integration theory, metric space topology, and elementary Banach space theory.

Theory of Functions of a Complex Variable I
(3-0) 3 hours credit. Prerequisite: MAT 3213 or 4213. Complex integration, Cauchy’s theorem, calculus of residues, and power series.

Theory of Functions of a Complex Variable II
(3-0) 3 hours credit. Prerequisite: MAT 5223. Infinite products, entire functions, Picard’s theorem, Riemann mapping theorem, and functions of several complex variables.

General Topology I
(3-0) 3 hours credit. Prerequisite: MAT 4273 or consent of instructor. Topological spaces, metric spaces, continua, and plane topology.

General Topology II
(3-0) 3 hours credit. Prerequisite: MAT 5243. Areas of study include introductory algebraic topology and introduction to topology of manifolds.
5263 **Applied Algebra**  
(3-0) 3 hours credit. Prerequisite: MAT 4233 or an equivalent.  
Areas of study include Boolean algebras, lattice theory and graph theory,  
finite fields, Lie groups, and Lie algebras.

5283 **Linear Algebra and Matrix Theory**  
(3-0) 3 hours credit. Prerequisite: MAT 2233 or an equivalent.  
A study of linear algebraic structures and algebraic properties of matrices.

5293 **Numerical Linear Algebra**  
(3-0) 3 hours credit. Prerequisite: MAT 2233 or an equivalent.  
Direct and iterative methods for solving general linear systems, the algebraic  
eigenvalue problem, least squares problems, and solutions of sparse systems  
arising from partial differential equations. (Same as CS 5293. Credit cannot  
be earned for both MAT 5293 and CS 5293.)

5313 **Algebra II**  
(3-0) 3 hours credit. Prerequisite: MAT 5173.  
Areas of study include: groups, rings, fields, Galois theory, ideal theory,  
and representations of groups, module theory, and homological algebra.

5403 **Functional Analysis I**  
(3-0) 3 hours credit. Prerequisites: MAT 2233, 4273, and 5203, or their  
equivalents.  
Topological vector spaces, inner product spaces, normed spaces, Hilbert  
spaces and Banach spaces, dual spaces, Hahn-Banach Theorem, and  
bounded linear operators.

5413 **Functional Analysis II**  
(3-0) 3 hours credit. Prerequisite: MAT 5403.  
Riesz representation theorem, spectral theory, Banach Algebras, and C*-  
Algebras.

5553 **Harmonic Analysis**  
(3-0) 3 hours credit. Prerequisites: Either MAT 3223 and MAT 4223 or  
consent of instructor.  
Theory of the Fourier, Laplace, and Hilbert transforms. Elements of the  
distribution theory. Harmonic functions. Function spaces: $L_p$-spaces, Hardy  
spaces, Sobolev spaces.

5603 **Numerical Analysis**  
(3-0) 3 hours credit. Prerequisite: MAT 3633 or consent of instructor.  
Emphasis on the mathematical analysis of numerical methods. Areas of  
study include solution of nonlinear equations and function optimization,  
approximation theory and numerical quadrature. (Same as CS 5603. Credit  
cannot be earned for both MAT 5603 and CS 5603.)
5613 Numerical Solutions of Differential Equations
(3-0) 3 hours credit. Prerequisite: MAT 5603 or an equivalent.
Emphasis on the mathematical analysis of numerical methods. Areas of
study include the analysis of single and multistep methods of ordinary
differential equations. Analysis of finite difference and finite element
methods for partial differential equations. (Same as CS 5613. Credit cannot
be earned for both MAT 5613 and CS 5613.)

5653 Differential Equations I
(3-0) 3 hours credit. Prerequisites: MAT 3613 and 4213, or consent of
instructor.
Solution of initial-value problems, linear systems with constant coefficients,
exponentials of operators, canonical forms and generic properties of
operators, and contractions.

5663 Differential Equations II
(3-0) 3 hours credit. Prerequisite: MAT 5653.
Dynamic systems, the fundamental existence and uniqueness theorem,
stability, the Poincare-Bendixson Theorem, introduction to perturbation,
and bifurcation theory.

5673 Partial Differential Equations I
(3-0) 3 hours credit. Prerequisite: MAT 3623, 5663, or consent of instructor.
Classical theory of initial value and boundary value problems for partial
differential equations.

5683 Partial Differential Equations II
(3-0) 3 hours credit. Prerequisite: MAT 5673.
Modern topics in partial differential equations.

5833 Perturbation Theory in Applied Mathematics
(3-0) 3 hours credit. Prerequisite: MAT 3613, 5653, or consent of instructor.
Perturbation theory, asymptotic analysis, and boundary layer expansions.

5973 Directed Research
3 hours credit. Prerequisites: Graduate standing and permission in writing
(form available) of the instructor and the student's graduate advisor of record.
The directed research course may involve either a laboratory or a theoretical
problem. May be repeated for credit, but not more than 6 hours, regardless
of discipline, will apply to the master's degree.

6603 Optimization Techniques in Operations Research
(3-0) 3 hours credit. Prerequisites: MAT 2213, 2233, or consent of instructor.
Analysis and application of optimization techniques in operations research.
Emphasis on linear programming, nonlinear programming, and integer
programming.
6901 Teaching Seminar
(1-0) 1 hour credit. Prerequisite: Designation as a teaching assistant in the Division of Mathematics and Statistics.
Designed to improve the instructional effectiveness of graduate students' teaching at the college level. Topics covered include board-work, clear speech, teacher-student interaction, professional responsibilities, course content and pace, grading policy, test writing, sensitivity to student needs, information and technical support and guest lecture(s) on special topics. The grade report for the course is either CR (satisfactory performance) or NC (unsatisfactory performance). This course may not be applied as credit toward a Master of Science degree in Mathematics.

6953 Independent Study
3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6961 Comprehensive Examination
1 hour credit. Prerequisite: Approval of the appropriate graduate studies committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

6973 Special Problems
(3-0) 3 hours credit. Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6983 Master's Thesis
3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.
COURSE DESCRIPTIONS
STATISTICS
(STA)

5073 Methods of Statistics I
(3-0) 3 hours credit. Prerequisite: STA 1053.
Emphasis on methods and applications of statistics. Measure of location,
variability, and association. Interpretation of categorical data. Hypothesis
testing. Use of SAS programs. Applications. May not be applied to a Master
of Science degree in Mathematics.

5083 Methods of Statistics II
(3-0) 3 hours credit. Prerequisite: STA 5073.
A continuation of STA 5073, with emphasis on linear statistical models.
Use of SAS programs. Applications. Topics in applied statistics which may
include maximum likelihood estimation and its properties; likelihood ratio
tests. Procedures in regression and model fitting. Transformations of data.
Analysis of variance and others. May not be applied to a Master of Science
degree in Mathematics.

5103 Applied Statistical Methods
(3-0) 3 hours credit. Prerequisite: STA 3523 or an equivalent.
Topics include graphical methods, estimation and hypothesis testing,
regression and model fitting, transformations of data, and analysis of
variance. Applications in science, biostatistics, engineering, and industry.

5133 Data Analysis with Statistical Software
(3-0) 3 hours credit. Prerequisites: CS 1713 and STA 3523, or their
equivalents.
Statistical analysis of data sets using SAS and several other popular
statistical software packages such as SPSSX, BMDP, and MINITAB, and
S-Plus. Manipulation of data sets and production of reports and graphs.
Emphasis on linear models and multivariate procedures. Importing and
exporting data from one package to another. Programming in the SAS
MATRIX/IML language.

5253 Applied Time Series Analysis
(3-0) 3 hours credit. Prerequisite: STA 5103 or consent of instructor.
Modern techniques for time series analysis and their applications. Principles
of model building. Regression methods, moving averages and autoregressive
integrated moving average models. Practical examples drawn from various
application environments. Use of software such as MINITAB, SAS, and S-
Plus in time series analysis.

5313 Theory of Sample Surveys with Applications
(3-0) 3 hours credit. Prerequisite: STA 3523.
Basic sampling techniques and their comparisons for finite populations.
Topics include simple random sampling, stratified sampling, ratio and
regression estimates, systematic sampling, cluster sampling, and multistage
and double sampling.
Nonparametric Statistics
(3-0) 3 hours credit. Prerequisite: STA 5103 or consent of instructor. Order statistics, test of goodness of fit, rank-order statistics, linear rank statistics for problems involving location and scale, association in multiple classifications, and asymptotic relative efficiency.

Mathematical Statistics I
(3-0) 3 hours credit. Prerequisites: MAT 4213 and STA 3513. Axioms of probability, random variables and probability distributions, sampling distributions, and stochastic convergence.

Mathematical Statistics II
(3-0) 3 hours credit. Prerequisite: STA 5503. Sufficient statistics, unbiased estimation, likelihood ratio test, sequential probability ratio test, and decision theory.

Linear Models I
(3-0) 3 hours credit. Prerequisites: MAT 2233 and either STA 5103 or consent of instructor. STA 4723 is strongly recommended but not required. Generalized inverse of matrix, least squares estimation in fixed models, linear estimable functions and Gauss-Markov theorem, multivariate normal distribution and distribution of quadratic forms, likelihood ratio tests in fixed models, and analysis of variance. Applications in full rank models and balanced models.

Linear Models II
(3-0) 3 hours credit. Prerequisite: STA 5713. Analysis of covariance, unbalanced models, random and mixed models, inference on variance components, and use of packaged programs.

Advanced Statistical Quality Control
(3-0) 3 hours credit. Prerequisite: STA 3523 or 5503. Acceptance sampling by attributes and by variables, military standard plans, rectifying inspection; tolerance limits; control chart for fraction defective, number of defects, and variables; cumulative sum charts, recent advances in control chart and acceptance sampling techniques.

Multivariate Analysis I
(3-0) 3 hours credit. Prerequisites: MAT 2233 and either STA 5103 or consent of instructor. Multivariate normal distribution, estimation of mean vector and covariance matrix, Hotelling's $T^2$, Wishart distribution, multivariate linear hypothesis testing, and analysis of variance.

Multivariate Analysis II
(3-0) 3 hours credit. Prerequisite: STA 5813. Tests concerning covariance matrices, canonical correlation, principal components, factor analysis, and cluster analysis. Application of packaged programs.
5853 Analysis of Categorical Data
(3-0) 3 hours credit. Prerequisite: STA 5103 or 5503.
Analysis of multifactor contingency tables: linear and log-linear models, inference in complete and incomplete tables, model selection and assessing goodness of fit, other methods of estimation such as information theoretic approach, minimum chi-square and logit chi-square, and measures of association. Models of discrete data.

5903 Theory of Reliability and Life Testing
(3-0) 3 hours credit. Prerequisite: STA 5503 or consent of instructor.
Probabilistic failure models, estimation and tests of hypotheses regarding these models, distribution-free methods, accelerated life testing, system reliability, and maintenance policies.

5973 Directed Research
3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6953 Independent Study
3 hours credit. Prerequisites: Graduate standing and permission in writing (form available) of the instructor and the student's graduate advisor of record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the master's degree.

6961 Comprehensive Examination
1 hour credit. Prerequisite: Approval of the appropriate graduate studies committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Studies Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either CR (satisfactory performance on the Comprehensive Examination) or NC (unsatisfactory performance on the Comprehensive Examination).

6973 Special Problems
(3-0) 3 hours credit. Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, will apply to the master's degree. (Same as former STA 5993. Not more than 6 hours of STA 5993 and Special Problems courses, regardless of discipline, will apply to the master's degree).
6983  Master's Thesis
3 hours credit. Prerequisites: Permission of the Graduate Advisor of Record and thesis director.
Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress.