COLLEGE OF SCIENCES
AND ENGINEERING
Master of Science Degree in Computer Science

The Master of Science degree program in Computer Science offers integrated studies involving software and hardware. A thesis option is available for students who wish 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. 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. Applicants are required to submit scores from the Graduate Record Examination (GRE).

Degree Requirements. Candidates for the degree are required to successfully complete 36 semester credit hours of graduate coursework.

A. The following four courses (12 hours) are required of all students:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 5513</td>
<td>Computer Architecture</td>
</tr>
<tr>
<td>CS 5523</td>
<td>Operating Systems</td>
</tr>
<tr>
<td>CS 5633</td>
<td>Analysis of Algorithms</td>
</tr>
<tr>
<td>CS 5363</td>
<td>Programming Languages and Compilers</td>
</tr>
</tbody>
</table>

B. Students must complete at least 18 semester credit hours of additional eligible graduate courses, 12 hours of which must be in the Division of Computer Science. With prior approval of the Graduate Advisor of Record, students may apply a maximum of 6 hours of graduate courses from other disciplines to the degree.

C. Students must either 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.

D. Candidates must either successfully defend 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 chapter 5, General Academic Regulations, and chapter 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 grade-point average of 3.30 or higher in the last 60 hours of coursework.
3. A score of at least 1500 on the GRE general test (verbal, math, and analytical sections); exceptions can be made in cases with a strong justification, such as a high grade-point average and/or extensive research. The GRE computer science subject test is strongly recommended but not required.
4. A TOEFL score of at least 550 for applicants whose native language is not English and who have not graduated from a U.S. institution.
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 résumé and a statement of research experience and interest.

Students who apply will automatically be considered for one of a small number of doctoral student stipends. Some teaching and research assistantships are also available.

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

A. Core courses (18 semester credit hours):

<table>
<thead>
<tr>
<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CS 5513</td>
<td>Computer Architecture</td>
</tr>
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<td>Operating Systems</td>
</tr>
<tr>
<td>CS 5633</td>
<td>Analysis of Algorithms</td>
</tr>
<tr>
<td>CS 6553</td>
<td>Performance Evaluation</td>
</tr>
<tr>
<td>CS 6643</td>
<td>Parallel Processing</td>
</tr>
<tr>
<td>CS 6653</td>
<td>Parallel Algorithms</td>
</tr>
</tbody>
</table>

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

1. High-Performance Programming Environments Focus:

<table>
<thead>
<tr>
<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CS 5113</td>
<td>Computer Graphics</td>
</tr>
<tr>
<td>CS 5363</td>
<td>Programming Languages and Compilers</td>
</tr>
</tbody>
</table>

   Plus two courses from the following:

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>CS 6113</td>
<td>Program Visualization and Monitoring</td>
</tr>
<tr>
<td>CS 6363</td>
<td>Advanced Compiler Construction</td>
</tr>
<tr>
<td>CS 6513</td>
<td>Advanced Computer Architecture</td>
</tr>
</tbody>
</table>

UTSA 1999–2001 Graduate Catalog
CS 6523 Distributed Operating Systems
CS 6543 Networks
CS 6593 Advanced Topics in Distributed Systems

2. High-Performance Computational Techniques Focus:
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. 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 other requirements.

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

Written Portion. 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. After the student has completed the coursework in his or her 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 is conducted by a faculty committee, which is chaired by the student’s program advisor. The oral exam consists 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 consists 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 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 the Master of Science degree 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. 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 include search, knowledge representation, planning, machine learning, and natural language processing. Programming projects are 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 are 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 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 an 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 3343. 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. 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. Topics 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 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 include neural network design, competitive learning, the CMAC model, adaptive resonance theory, bidirection 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 4713 or 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.

6463  **Advanced Topics in Computer Science**  
(3-0) 3 hours credit. Prerequisite: Graduate standing and consent of instructor.  
Advanced topics in an area of computer science. May be repeated for credit when topics vary.

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.

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.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisite(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6593</td>
<td>Advanced Topics in Distributed Systems</td>
<td>3 hours</td>
<td>CS 5523.</td>
<td>Advanced topics in distributed systems. May be repeated for credit when topics vary.</td>
</tr>
<tr>
<td>6613</td>
<td>Parallel Numerical Methods and Software</td>
<td>3 hours</td>
<td>CS 5523, CS 5603, and 6643.</td>
<td>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.</td>
</tr>
<tr>
<td>6643</td>
<td>Parallel Processing</td>
<td>3 hours</td>
<td>CS 5513 and 5523.</td>
<td>Parallel models of computation, performance measurement, and modeling of parallel algorithms and application studies on parallel computers.</td>
</tr>
<tr>
<td>6653</td>
<td>Parallel Algorithms</td>
<td>3 hours</td>
<td>CS 5513 and 5633.</td>
<td>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.</td>
</tr>
<tr>
<td>6693</td>
<td>Advanced Topics in Application Development</td>
<td>3 hours</td>
<td>Consent of instructor.</td>
<td>Advanced applications in applications development. May be repeated for credit when topics vary.</td>
</tr>
<tr>
<td>6723</td>
<td>Image Processing</td>
<td>3 hours</td>
<td>Consent of instructor.</td>
<td>Topics include image acquisition, enhancement, transformations, filters, compression, segmentation, and edge detection, morphology, and recognition.</td>
</tr>
<tr>
<td>6953</td>
<td>Independent Study</td>
<td>3 hours</td>
<td>Graduate standing and permission in writing (form available) of the instructor and student’s graduate advisor of record.</td>
<td>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.</td>
</tr>
<tr>
<td>6961</td>
<td>Comprehensive Examination</td>
<td>1 hour</td>
<td>Approval of the appropriate graduate studies committee to take the Comprehensive Examination.</td>
<td>Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Studies Committee.</td>
</tr>
</tbody>
</table>
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: Consent of 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: Consent 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: Successful completion of the written part of the Qualifying Examination.
May be repeated for credit, but no more than 12 hours may be applied to the Ph.D. degree requirements. (Formerly CS 7243.)

7311-3 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 students the opportunity to acquire a sound preparation of the fundamentals in several areas of chemistry, to introduce students 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 when application is made for admission to UTSA.

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

Applicants must submit scores from the Graduate Record Examination (GRE).

A minimum of two letters of recommendation from persons familiar with the applicant's undergraduate scholastic record must be sent 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. Candidates must complete the following:

A. Required courses (25 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CHE 5113</td>
<td>Advanced Organic Chemistry I</td>
<td>3 hours</td>
</tr>
<tr>
<td>CHE 5133</td>
<td>Advanced Inorganic Chemistry</td>
<td>3 hours</td>
</tr>
<tr>
<td>CHE 5163</td>
<td>Advanced Instrumental Analysis</td>
<td>3 hours</td>
</tr>
<tr>
<td>CHE 5192</td>
<td>Advanced Spectral Measurement and Interpretation I</td>
<td>2 hours</td>
</tr>
<tr>
<td>CHE 5202</td>
<td>Advanced Spectral Measurement and Interpretation II</td>
<td>2 hours</td>
</tr>
</tbody>
</table>
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 CHE 5271 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 Dean of Graduate Studies for approval.

Nonthesis Option in Chemistry

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

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>
<tr>
<td>CHE 5202</td>
<td>Advanced Spectral Measurement and Interpretation II</td>
<td>2</td>
</tr>
<tr>
<td>CHE 5213</td>
<td>Chemical Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>CHE 5271</td>
<td>Graduate Seminar in Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHE 5973</td>
<td>Directed Research</td>
<td>6</td>
</tr>
</tbody>
</table>

Registration for CHE 5271 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 taken as Independent Study and completed before 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. Enrollment will normally be limited to M.S. degree-seeking students. A regularly scheduled topics course linked with CHE 5202 (spring semester) including experimentation, data analysis, and problem solving using modern chemical instrumentation. In the CHE 5192 and CHE 5202 sequence, 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 topics vary, but no more than 2 semester credit hours can be applied to the master’s degree. A grade of RP will be given in CHE 5192 until both CHE 5192 and CHE 5202 are completed. This occurs when the student has shown competency in a minimum of three techniques.
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. Enrollment will normally be limited to M.S. degree-seeking students.
A regularly scheduled topics course linked with CHE 5192 (fall semester) including experimentation, data analysis, and problem solving using modern chemical instrumentation. In CHE 5192 and CHE 5202 sequence, 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 topics vary, but no more than 2 semester credit hours can be applied to the master's degree. A grade of RP will be given in CHE 5202 until both CHE 5192 and CHE 5202 are completed; this occurs when the student has shown competency in a minimum of three techniques.

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.

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.

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.

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.

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.
5513 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.

5623 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.

5902 Teaching Seminar  
(1-2) 2 hours credit. Prerequisite: Graduate standing in chemistry and concurrent designation as a teaching assistant in the chemistry program, 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.

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. 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.

6113 Advanced Organic Chemistry II  
(3-0) 3 hours credit. Prerequisite: CHE 5113 or consent of instructor.  
Study of organic reaction mechanisms.

6123 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 not 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 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, applicants must satisfy the following:

1. Submission of results on the Graduate Record Examination (GRE) or equivalent score on other relevant tests to the Office of Graduate Studies
2. Preferable completion of the following:
   a. One semester of organic chemistry and two semesters of physical chemistry
   b. A statistics course equivalent to STA 1993 Statistical Methods for the Life and Social Sciences
   c. Two semesters of biology or other life sciences coursework
3. Two or more letters of recommendation from people familiar with the applicant’s undergraduate scholastic record, sent to the Director of the Division of Earth and Physical Sciences when application for admission is made

Applicants who do not meet these program admission requirements may be considered on an individual basis by the Graduate Studies Committee.
Thesis Option in Environmental Sciences

Degree Requirements. The Master of Science program in Environmental Sciences requires completion of a minimum of 33 semester credit hours (exclusive of coursework or other study required to remove deficiencies).

Candidates for the degree must complete the following:

A. Required courses (27 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 5023</td>
<td>Environmental Statistics</td>
<td>3</td>
</tr>
<tr>
<td>ES 5033</td>
<td>Geographical Information Systems</td>
<td>3</td>
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<tr>
<td>ES 5103</td>
<td>Environmental Ecology</td>
<td>3</td>
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<tr>
<td>ES 5123</td>
<td>Project Analysis</td>
<td>3</td>
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<td>ES 5403</td>
<td>Industrial Process</td>
<td>3</td>
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<tr>
<td>ES 5503</td>
<td>Environmental Regulations</td>
<td>3</td>
</tr>
<tr>
<td>ES 5803</td>
<td>Environmental Planning and Management</td>
<td>3</td>
</tr>
<tr>
<td>ES 6983</td>
<td>Master’s Thesis</td>
<td>6</td>
</tr>
</tbody>
</table>

Registration for ES 6983 Master’s Thesis is required for each semester of residence, although no more than 6 semester credit hours can be applied to the degree.

B. 6 semester credit hours at the advanced level (6000 level) in environmental sciences, as approved by the Graduate Advisor of Record, are required. Independent Study and Internship hours may not be counted toward the thesis option in environmental sciences.

Nonthesis Option in Environmental Sciences

Degree Requirements. The nonthesis option requires completion of a minimum of 36 semester credit hours (exclusive of coursework or other study required to remove deficiencies).

Candidates for the degree must complete the following:

A. Required courses (24 semester credit hours):

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<thead>
<tr>
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<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 5023</td>
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<td>ES 5503</td>
<td>Environmental Regulations</td>
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<tr>
<td>ES 5803</td>
<td>Environmental Planning and Management</td>
<td>3</td>
</tr>
<tr>
<td>ES 6893</td>
<td>Professional Report</td>
<td>3</td>
</tr>
</tbody>
</table>

Registration for ES 6983 Professional Report requires each student to prepare a scholarly paper suitable for publication. A draft must be presented to the student’s graduate advisory committee for review and approval. The student is also required to present the paper at an open seminar.
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B. 12 semester credit hours of elective support work:

Option 1. 12 semester credit hours of graduate courses constituting a coherent program of scholarship with at least 9 semester credit hours selected from the 6000-level environmental sciences courses.

Coursework in this option must have the approval of the Graduate Advisor of Record. Outside coursework must clearly support the student’s program of study.

Option 2. 6 to 9 semester credit hours of graduate courses in a single related discipline in which a student has the required prerequisites. Outside coursework must support a specialization within environmental sciences, such as biology, chemistry, civil engineering, or geology.

3 to 6 semester credit hours of 6000-level graduate courses in environmental sciences.

C. Students pursuing the nonthesis option may not apply more than 3 hours of Independent Study, 6 hours of Internship, or any combination that totals more than 6 semester credit hours.

D. Candidates are required to pass an oral comprehensive examination after they have completed at least 30 semester credit hours of coursework. ES 6961 Comprehensive Examination (1 hour) may not be applied to the 36-semester-credit-hour minimum.

COURSE DESCRIPTIONS
ENVIRONMENTAL SCIENCES
(ES)

5023 Environmental Statistics
(3-0) 3 hours credit. Prerequisites: MAT 1033 and STA 1993 or their equivalent, and consent of instructor. Introductory course in systems analysis emphasizing its application for the management of environmental and public systems. Problem formulation, mathematical modeling, and procedures are introduced through case studies that include energy consumption, soil contamination, leak detection, and air pollution. In these case studies, students become acquainted with quantitative governmental regulations formalized by the Environmental Protection Agency. Quantitative tools include exploratory data analysis, design of experiments, analysis of variance, regression analysis, and time series. Optimization techniques are taught within regression analysis.

5033 Geographical Information Systems
(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 databases 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.)
5103 **Environmental Ecology**  
(3-0) 3 hours credit.  
The impact of humanity's activities on the environment: their effect on water, land, animal, and human resources. An evaluation of present and future strategies to preserve a healthy environment. (Formerly ENV 6613 and ES 6203. Credit cannot be earned for ES 5103, and either ENV 6613 or ES 6203.)

5123 **Project Analysis**  
(3-0) 3 hours credit.  
This course examines the complex processes and factors in the evaluation of large-scale projects involving natural resources. It brings together the tools required to evaluate the physical, economic, financial, legal, and political constraints of these projects. (Formerly ENV 6873 and ES 6873. Credit cannot be earned for ES 5123, and either ENV 6873 or ES 6873.)

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 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 5023 or consent of instructor.
Advanced application of systems analysis to the solution of environmental problems and the building and solving of mathematical models. The role of analytical tools such as cost analysis, decision, and utility theory as they are applied to the efficient utilization of natural resources are also covered. (Formerly ENV 6903. Credit cannot be earned for both ES 6003 and ENV 6903.)

6013 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 for detecting environmental pollutants. EPA-approved techniques are emphasized. (Formerly ENV 5013 and ES 5013. Credit cannot be earned for ES 6013, and either ENV 5013 or ES 5013.)

6103 Environmental 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 and ES 5203. Credit cannot be earned for ES 6103, and either ENV 5533 or ES 5203.)

6513 Advanced GIS
(2-2) 3 hours credit. Prerequisite: ES 5033 or consent of instructor.
Geographic Information Systems are an excellent tool for modeling environmental systems and managing or processing environmental data. This course uses ArcView, ArcView Spacial Analyzer, and PC ArcInfo to solve and model environmental problems, including hazardous waste remediation, regulatory compliance, environmental feature mapping, groundwater contamination, and air pollution. Global Positioning Systems
are used to map environmental features in field studies. Additional topics include digitizing, topology correction, geographic projections, and geopositioning of images.

**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 aspects of professional practice are covered. (Formerly ENV 5023. Credit cannot be earned for both ES 6523 and ENV 5023.)

**6533 Diplomacy and Ethics for Resource Management**  
(3-0) 3 hours credit.  
Exploration of issues embedded in resource diplomacy and ethics in the twenty-first century. Resource diplomacy and ethics are examined in the context of technology, economics, and institutions.

**6813 Water Resources**  
(3-0) 3 hours credit.  
Application of management principles to the efficient use of water resources by people and their public and private institutions. Water is examined in terms of its value, use, and changing role in the context of economics, history, politics, and technology. (Formerly ENV 6813. Credit cannot be earned for both ES 6813 and ENV 6813.)

**6823 Land Resources**  
(3-0) 3 hours credit. Prerequisite: ES 5033 or consent of instructor.  
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 related 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.)
Solid Waste Management  
(3-0) 3 hours credit.  
Practical aspects of solid waste management, with emphasis placed on the interrelationship of environmental, economic, institutional, and technological 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.)

Professional Report  
3 hours credit. Prerequisite: Permission of the Graduate Advisor of Record and the faculty advisor or director. Research and preparation of an in-depth study of a complex environmental problem. Credit will be awarded upon completion of the written professional report.

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).

Internship  
3 to 6 hours credit. Prerequisite: Graduate standing, 21 semester hours of graduate work, and consent of Graduate Advisor of Record. An opportunity for students to work in a setting that permits them to apply what they have learned in the formal instruction part of the program. May be repeated for credit, but not more than 6 hours will apply to the master’s degree.

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 Master of Science degree program in Geology offers students the opportunity for advanced study and research leading to the M.S. degree in the following emphasis areas: water resources (hydrogeology), environmental geology, and 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 when 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.

Applicants must submit scores from the Graduate Record Examination (GRE). Three letters of recommendation should be sent to the Director of the 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.

Candidates for the degree must complete

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

GEO 5991 Graduate Seminar in Geology 2 hours
GEO 6983 Master’s Thesis 6 hours

No more than 2 semester credit hours of GEO 5991 Graduate Seminar and 6 semester credit hours of GEO 6983 Master’s Thesis can be applied to the master’s degree.

B. Candidates must choose one of the following three emphases:
Water Resources (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

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

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

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

Nonthesis Option in Geology

The nonthesis option applies only to the Water Resources (Hydrogeology) and Environmental Geology emphases.

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

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 hours of GEO 5991 Graduate Seminar and 3 hours of GEO 5973 Directed Research can be applied to the master's degree

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B. Candidates must choose one of the following two emphases:

Water Resources (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

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. Candidates are required to pass an oral comprehensive examination after they have 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.

COURSE DESCRIPTIONS
GEOL OGY
(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.
Advanced Geomorphology
(3-2) 4 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. Field trips required. (Formerly GEO 5303. Credit cannot be earned for both GEO 5303 and GEO 5304.)

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 are examined. Field trips required.

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.

Advanced Stratigraphy
(3-3) 4 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. Sequence stratigraphy and seismic and log analyses are studied. Field trips required. (Formerly GEO 5503. Credit cannot be earned for both GEO 5503 and GEO 5504.)

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 groundwater; emphasis on hydrology, flow system evolution and aquifer analysis. Field trips required.

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.

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, written reports, and field trips 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 and maturation of the basin fill, and timing of events. Case histories of various basins illustrate approaches. Field trips required.

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 focuses 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. Financial assistance is awarded on a competitive basis.

COURSE DESCRIPTIONS

ENGINEERING

(EGR)

5013 Analytic Techniques in Engineering Analysis
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or consent of instructor.
Advanced methods of applied mathematics, including linear algebra, vector differential calculus, integral theorems, differential equations, and calculus of variations.

5023 Numerical Techniques in Engineering Analysis
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or consent of instructor.
Advanced methods of applied mathematics, including numerical linear algebra, initial value problems, stability, convergence, partial differential equations, and optimization.

5093 Special 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 1: Applied Operations Research. Application of operations research 
methods to practical engineering problems. 
Topic 2: Engineering Systems Modeling. Modeling of modern engineering 
systems for operational and management control. 
May be repeated for credit as topics vary.

5233  **Advanced Quality Control**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or consent 
of instructor. 
Methods and techniques for process control, process and gage capabilities, 
inspection plans, American National Standard, and recent advanced 
techniques. Tour of manufacturing industry. Case studies in process control, 
outgoing quality, and costs. A project, assigned by a manufacturing company, 
is required, along with a final presentation of the project.

5303  **Continuum Mechanics**  
(3-0) 3 hours credit. Prerequisite: EGR 2503 or an equivalent, or consent of 
instructor. 
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.

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.

5543 Foundations of Solid Mechanics  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Variational mechanics, energy methods, elementary viscoelastic/plastic problems, and wave propagation.

5553 Advanced Strength of Materials  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Analysis of stress and strain, two-dimensional problems in elasticity, failure theories, bending, torsion, elastic stability, and energy methods. (Formerly topic one of EGR 5233. Credit cannot be earned for both EGR 5533 and EGR 5553.)

5563 Elasticity  
(3-0) 3 hours credit. Prerequisite: EGR 3213 or an equivalent, or consent of instructor.  
Equilibrium, compatibility equations, strain energy methods, torsion of noncircular sections, flexure, and axially symmetric problems. (Formerly topic two of EGR 5233. Credit cannot be earned for both EGR 5533 and EGR 5563.)

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 and services that are spawned by innovators using new and emerging technologies. Seminar format, case-study preparation, presentation, and cooperative learning are 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 is ecological, historical, and institutional. Seminar format, issue paper preparation and presentation, and cooperative learning are defining characteristics of this course.
Master of Science Degree in Civil Engineering

The Master of Science degree 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. Civil engineering education and research activities focus 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.

Students interested in emphasizing construction management may take selected courses in architecture, civil engineering, finance, and management of technology.

Program Admission Requirements. In addition the University-wide graduate admission requirements for unconditional admission, applicants satisfy the following:

1. a satisfactory score, as specified by the Graduate Studies Committee for Civil Engineering, on the Graduate Record Examination (GRE)
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 degree, 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. Each candidate is required to pass a comprehensive examination and/or a thesis defense administered by his or her advisory committee, which is 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 chair 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>
<tr>
<td>Thesis</td>
<td>6</td>
</tr>
<tr>
<td>Total semester credit hours required</td>
<td>30</td>
</tr>
</tbody>
</table>

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Nonthesis Option

Designated electives (approved by the chair 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 nonprismatic 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, sheet pile 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 1: Civil Engineering Project Analysis. Planning, implementation, control, and evaluation methods for special civil engineering projects.
Topic 2: Advanced Civil Engineering Technology Transfer. Civil engineering technology development and transfer for real-world problems.
Topic 3: Advanced Civil Engineering Design. Project-oriented design course involving advanced civil engineering 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.
Topic 4: Pavement Management Systems. Methodologies to evaluate and summarize pavement network conditions and priorities for mainframes.
Topic 5: Pavement Design. Design and analysis of pavement structural systems.

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 degree 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 students who want the
opportunity to obtain some expertise in research. A nonthesis option is available for
students who want 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
Graduate Record Examination (GRE).
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 must have a minimum
grade-point average of 2.75 in the last 60 hours and a minimum total score of
1100 on the verbal and quantitative portions of the GRE. Students must take
three graduate core courses and earn higher than 3.0 in those courses before
unconditional admission to the graduate program is granted.
2. Students with science or other engineering undergraduate degrees must have
taken 6 hours (4000-level) of undergraduate electrical engineering courses for
graduate credit in lieu of the courses outside of electrical engineering and four of
the five graduate core courses in electrical engineering.
a. A minimum grade-point average of 3.0 in the last 60 hours and a minimum
total score of 1100 on the verbal and quantitative portions of the GRE may
result in conditional admission. The Electrical Engineering Graduate Studies
Committee may suggest or require a list of undergraduate courses to make
up deficiencies in the undergraduate electrical engineering curriculum before

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unconditional admission to the graduate program is granted. Courses listed as deficiencies do not count toward the graduate degree.

b. A minimum grade-point average of 2.75 in the last 60 hours and a minimum total score of 1100 on the verbal and quantitative portions of the GRE may result in conditional admission. Students must take undergraduate courses as specified by the Electrical Engineering Graduate Studies Committee and maintain minimum grades of 3.0 to make up deficiencies in the undergraduate electrical engineering curriculum. Courses listed as deficiencies do 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 do not intend to pursue the Master of Science degree in Electrical Engineering 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 program:

<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:

**Thesis Option**
- Core courses (any three) 9 hours
- Additional graduate electrical engineering courses* 9 hours
- Electives (may be courses from outside electrical engineering)* 6 hours
- EE6983 Master’s Thesis 6 hours
- EE5991 Graduate Seminar 1 hour
- Minimum total semester credit hours required 31 hours

**Nonthesis Option**
- Core courses (any four) 12 hours
- Additional graduate electrical engineering courses* 15 hours
- Electives (may be courses from outside electrical engineering)* 6 hours
- EE5991 Graduate Seminar 1 hour
- Minimum total semester credit hours required 34 hours

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, candidates are required to pass a comprehensive exam.

*Chosen with the approval of the Electrical Engineering Graduate Studies Committee
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 the following:


Topic 2: Automatic Test Equipment. Techniques and standards for ATE; VXIbus, IEEE-488, and SCPI.

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 the following:  
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 CIO, 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 the following:  
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 the following:  
Topic 1: Nonlinear Filters. Order statistic filters, morphological filters, stack/Boolean filters, and other related topics.  
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 the following:
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.

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 transforms, 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. The grade report for the course is either CR (satisfactory performance) or NC (unsatisfactory performance).

6323 Advanced Topics in Computers
(3-0) 3 hours credit. Prerequisite: 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. Prerequisite: 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. Prerequisite: 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. Prerequisite: 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 students who want the opportunity for research. A nonthesis option is available for students who want additional professional engineering education.

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

1. Minimum scores of 400 on the verbal portion and 600 on the quantitative portion of the Graduate Record Examination.
2. A bachelor’s degree in mechanical engineering or a closely related field from an accredited institution of higher education, or proof of equivalent training at a foreign or unaccredited institution
An applicant who does not qualify for unconditional admission may be admitted on a conditional basis as determined by the Master of Science in Mechanical Engineering Admission Committee. 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 is granted. Courses listed as deficiencies do not count toward the graduate degree.

Applicants with a mechanical engineering background who wish to continue their education but do not intend to pursue a Master of Science degree in Mechanical Engineering are encouraged to seek admission as special graduate students.

**Degree Requirements.** The minimum number of semester credit hours required for the degree, excluding required coursework to remove admission deficiencies, is 30 for the thesis option and 36 for the nonthesis option.

**A.** Degree candidates must complete the following 6 semester credit hours of core courses within the first 18 hours of graduate coursework:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 5013</td>
<td>Analytic Techniques in Engineering Analysis</td>
</tr>
<tr>
<td>EGR 5023</td>
<td>Numerical Techniques in Engineering Analysis</td>
</tr>
</tbody>
</table>

**B.** Degree candidates must complete the following course requirements for one of the degree options:

**Thesis Option**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 5013</td>
<td>Analytic Techniques in Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EGR 5023</td>
<td>Numerical Techniques in Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Designated electives (approved by the student’s advisory committee chair)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Master’s Thesis</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

Minimum total semester credit hours required: 30

**Nonthesis Option**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 5013</td>
<td>Analytic Techniques in Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EGR 5023</td>
<td>Numerical Techniques in Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Designated electives (approved by the student’s advisory committee chair)</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Minimum total semester credit hours required: 36

In addition to the coursework and other University requirements for the master's degree, candidates must pass a comprehensive examination or a thesis defense administered by the student’s advisory committee, chaired by a full-time graduate faculty member. A successful thesis defense satisfies the comprehensive exam requirement. Candidates for a nonthesis degree must pass a written and oral comprehensive exam. No more than two attempts will be allowed to pass the comprehensive exam.
Degree-seeking students must select a major advisor and a graduate advisory committee (with a minimum of three members) in the first 12 hours of graduate coursework. The chair of the student’s advisory committee, who must be a full-time member of the graduate faculty, is the student’s primary advisor. Within the first 12 hours of graduate coursework, degree candidates must meet with the committee chair to develop a degree plan for their program of study. New students who have not selected a graduate advisory committee should seek advice from the Graduate Advisor of Record on course selection during the first semester.

**COURSE DESCRIPTIONS**
**MECHANICAL ENGINEERING**
*(ME)*

5013 **Topics in Mechanical Engineering**
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or consent of instructor.
Current topics in mechanical engineering. May be repeated for credit as topics vary.

5143 **Advanced Dynamics**
(3-0) 3 hours credit. Prerequisites: ME 3323 or an equivalent, and ME 3423 or an equivalent.
Analytical dynamics, including Newton-Euler, Lagrange, and Hamilton’s principles; gyroscopic effects; stability.

5153 **Structural Dynamics**
(3-0) 3 hours credit. Prerequisites: ME 3323 or an equivalent, and ME 3423 or an equivalent.
Matrix methods for analysis of dynamics of complex structures, computer solutions, systems identifications, and experimental model analysis.

5163 **Dynamics of Rotating Machinery**
(3-0) 3 hours credit. ME 3323 or an equivalent, and ME 3423 or an equivalent.
Dynamic stability, critical speeds, and unbalanced response of rotor-bearing systems; operation through and above critical speeds.

5173 **Nonlinear Systems and Chaos**
(3-0) 3 hours credit. Prerequisites: ME 3323 or an equivalent, and ME 3423 or an equivalent.
Phase-space representation, local and global stability, time and frequency domain characterization, and applications to oscillatory systems in various engineering disciplines.

5243 **Advanced Thermodynamics**
(3-0) 3 hours credit. Prerequisite: ME 3293 or an equivalent.
Concepts and postulates of macroscopic thermodynamics; formulation or thermodynamic principles; stability of thermodynamic systems.
5253 Thermodynamics of Materials
(3-0) 3 hours credit. Prerequisite: ME 3293 or an equivalent.
Phase equilibria, solutions, phase rule, phase diagrams, defects in solids,
surfaces and interfaces, diffusion, and transformations.

5303 Advanced Heat and Mass Transfer
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or
consent of instructor.
Derivation of energy and mass conservation equations with constitutive laws
for conduction, convection, radiation and mass diffusion. Dimensional
analysis, heat exchangers, boiling and condensation, steady and transient
solutions.

5333 Conduction
(3-0) 3 hours credit. Prerequisite: ME 4313 or an equivalent.
Derivation of governing equations, steady and transient solutions, variable
property effects, numerical methods.

5343 Convection
(3-0) 3 hours credit. Prerequisite: ME 4313 or an equivalent.
Derivation of equations of convection of mass, momentum, and energy;
scale analysis; boundary layer solutions; classical, laminar convection
problems; turbulent convection.

5353 Radiation
(3-0) 3 hours credit. Prerequisite: ME 4313 or an equivalent.
Thermal radiation laws; geometric factors, black bodies; gray enclosures;
nongray systems; combined conduction, convection, and radiation.

5363 Mass Transfer
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering or
consent of instructor.
Conservation principles, constitutive laws, diffusion, porosity, permeability,
retardation, and dispersion. Single- and multiphase flow under isothermal
and nonisothermal conditions.

5423 Mechanical Vibrations
(3-0) 3 hours credit. Prerequisites: ME 4513 or an equivalent, and ME 3423
or an equivalent.
Dynamics of high-order lumped-component systems, model testing, system
identification, design and control; approximate methods.

5433 Nonlinear Vibrations
(3-0) 3 hours credit. Prerequisites: ME 4513 or an equivalent, and ME 3423
or an equivalent.
Classic methods in nonlinear analysis; modern techniques for analysis of
deterministic and chaotic behavior.
5443 **Random Vibrations**  
(3-0) 3 hours credit. Prerequisite: ME 4513 or an equivalent, and ME 3423 or an equivalent.  
Randomly excited mechanical systems and structures; stationary and ergodic processes; first passage and fatigue failures; data analysis techniques.

5513 **Advanced Mechanism Design**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering.  
Advanced topics in kinematic synthesis of linkage, static and dynamic force analyses, and computer-aided design of mechanisms.

5533 **Advanced Machine Design**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering.  
Advanced problems in machine design, including bearings, brakes and clutches, gears, shafts, springs; advanced stress analysis.

5543 **Probabilistic Engineering Design**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering.  
Stochastic methods in mechanical engineering design; probability density generation, probabilistic analysis, and random processes.

5553 **Advanced Design of Cams and Gears**  
(3-0) 3 hours credit. Prerequisite: Graduate standing in engineering.  
Advanced problems in design of cam follower systems; gear trains and spur, helical, bevel, and worm gears.

5613 **Advanced Fluid Mechanics**  
(3-0) 3 hours credit. Prerequisite: ME 3663 or an equivalent.  
Dynamics of incompressible fluid mechanics viscous flow; Navier-Stokes equations; boundary layer theory; and numerical operations for incompressible fluid flow.

5623 **Two-Phase Flow**  
(3-0) 3 hours credit. Prerequisites: ME 3663 or an equivalent, and ME 4313 or an equivalent.  
Basic treatment of two-phase flow; detailed analysis of flow of suspended particles, bubbles, and mists; analysis of slug and annular flows; measurement techniques.

5633 **Gas Dynamics**  
(3-0) 3 hours credit. Prerequisite: ME 3663 or an equivalent.  
Integral and differential forms of the conservation equations, one-dimensional flow, oblique shock and expansion waves, and supersonic, transonic, and hypersonic flows.

5643 **Boundary Layer Theory**  
(3-0) 3 hours credit. Prerequisite: ME 3663 or an equivalent.  
Viscous flow, integral and differential equations of motion, and exact and numerical solutions for laminar and turbulent flows.
5653 **Computational Fluid Dynamics**
(3-0) 3 hours credit. Prerequisite: ME 3663 or an equivalent.
The mathematical models for fluid-flow simulations at various levels of approximation, basic description techniques, and the nature of flow equations and their boundary conditions.

5683 **Advanced Design of Thermal and Fluid Systems**
(3-0) 3 hours credit. Prerequisites: ME 3663 or an equivalent, and EE 4313 or an equivalent.
Development of energy systems, power systems, and the mechanics of combustion.

5713 **Mechanical Behavior of Materials**
(3-0) 3 hours credit. Prerequisite: ME 2243 or an equivalent, or consent of instructor.
Mechanical behavior of engineering materials (metals, alloys, ceramics, and polymers) elasticity, dislocation theory, strengthening mechanism, fracture, fatigue, creep, and oxidation.

5723 **Materials Characterization**
(3-0) 3 hours credit. Prerequisite: ME 2243 or an equivalent, or consent of instructor.
Basic theory and application of techniques used to characterize engineering materials. Techniques discussed include X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron spectroscopy (SIMS), and thermal analysis. Practice demonstrations and projects.

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 who want an opportunity to develop expertise in research techniques and data analysis; a nonthesis option is offered for those who want the opportunity to earn the master of science degree primarily through organized coursework. The thesis option is recommended for students who plan a career in research or 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 when 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. To be considered for degree-seeking status, applicants must submit two letters of recommendation to the Graduate Studies Committee Chair in the Division of Life Sciences; they must also submit scores from the Graduate Record Examination with their application. A total of 1000 on the verbal and quantitative sections of the general test is required, but exceptions may be made depending on grade-point average and letters of recommendation.

Degree Requirements. Degree candidates are required to complete a minimum of 36 semester credit hours approved by the student's graduate advisor of record. These hours are 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 may include up to 6 semester credit hours of approved upper-division undergraduate coursework and a maximum of 3 semester credit hours in a graduate seminar (BIO 7051).

2. An additional 18 semester hours of graduate credit as approved by the Graduate Advisor of Record. This 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 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, candidates must pass a comprehensive examination administered by their graduate committee. This exam is normally given in the semester before 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 these committees, and no more than one member of either committee can be a nontenured or nontenure-track faculty member, or be from another university. Students electing the thesis option must successfully defend their thesis research before their graduate committee prior to the submission of the thesis to the Dean of Graduate Studies 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 field of applied biology. A broad common base of knowledge for biotechnology is provided in the master's degree by a comprehensive core curriculum that encompasses key areas in biology, computer science, and statistics. Additional coursework is selected from one of two concentrations, from which specialized courses may be chosen. These concentrations are molecular neurobiology and bioprocessing technology. 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 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. Courses listed as deficiencies do not count toward the graduate degree. In such cases, students should anticipate that additional time will be required to complete the degree. To be considered for degree-seeking status, applicants must submit two letters of recommendation to the Graduate Studies Committee Chair in the Division of Life Sciences; they must also submit scores from the Graduate Record Examination with their application. A total of 1000 on the verbal and quantitative sections of the general test is required, but exceptions may be made depending on grade-point average and letters of recommendation.

Program of Study

A. Biotechnology core curriculum (18 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5353</td>
<td>Molecular and Biochemical Genetics</td>
</tr>
<tr>
<td>BIO 6803</td>
<td>Advanced Immunology and Immunochemistry</td>
</tr>
<tr>
<td>BIO 7051</td>
<td>Seminar in Life Sciences (must be repeated three times)</td>
</tr>
</tbody>
</table>

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B. Biotechnology electives. Each student must complete 18 semester credit hours of biotechnology electives, at least 9 of which must be selected from a single concentration:

**Concentration 1: Molecular Neurobiology**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5423</td>
<td>Neuroanatomy</td>
</tr>
<tr>
<td>BIO 5433</td>
<td>Neurophysiology</td>
</tr>
<tr>
<td>BIO 5443</td>
<td>Neurochemistry</td>
</tr>
<tr>
<td>BIO 5523</td>
<td>Enzymes</td>
</tr>
<tr>
<td>BIO 5563</td>
<td>Biochemical Macromolecules</td>
</tr>
<tr>
<td>BIO 5833</td>
<td>Membrane Structure and Function</td>
</tr>
<tr>
<td>BIO 7571-3</td>
<td>Experimental Techniques in the Life Sciences</td>
</tr>
</tbody>
</table>

**Concentration 2: Bioprocessing Technology**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5363</td>
<td>Microbial Genetics</td>
</tr>
<tr>
<td>BIO 5523</td>
<td>Enzymes</td>
</tr>
<tr>
<td>BIO 5563</td>
<td>Biochemical Macromolecules</td>
</tr>
<tr>
<td>BIO 6553</td>
<td>Fermentation Science</td>
</tr>
<tr>
<td>BIO 6563</td>
<td>Food Science and Technology</td>
</tr>
<tr>
<td>BIO 6873</td>
<td>Microbial Physiology and Energetics</td>
</tr>
<tr>
<td>BIO 7571-3</td>
<td>Experimental Techniques in the Life Sciences—Monoclonal Antibodies and Flow Cytometry</td>
</tr>
<tr>
<td>BIO 7571-3</td>
<td>Experimental Techniques in the Life Sciences—Recombinant DNA</td>
</tr>
<tr>
<td>BIO 7571-3</td>
<td>Experimental Techniques in the Life Sciences—Tissue Culture and Somatic Cell Genetics</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

D. Master’s thesis option. Students electing the thesis option must complete 6 semester credit hours of BIO 6983 Master’s Thesis

**Comprehensive Examination.** As specified by University regulations, degree candidates must pass a comprehensive examination administered by their graduate committee. This exam is normally given in the semester before 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 these committees, and no more than one member of either committee can be a nontenured or nontenure-track faculty member, or be from another university. The examination is normally given in the semester before the semester during which the degree requirements are to be completed. Students electing the thesis option must successfully defend their thesis research before their graduate committee before the submission of the thesis to the Dean of Graduate Studies for approval.
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 has emphases in molecular and cellular neurobiology. The Ph.D. in Biology is awarded to candidates who have displayed an in-depth understanding of the subject matter and 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 chapter 5, General Academic Regulations, and chapter 7, Doctoral Degree Regulations).

**Admission Requirements.** Applicants must have a B.A. or a B.S. degree from an accredited university and a minimum grade-point average of 3.0 in upper-division and graduate work, preferably in biology. They should also have a minimum combined score on the verbal and quantitative portions of the Graduate Record Examination of 1000. Exceptions can be made in cases with a strong justification (e.g., high grade-point average 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, is responsible for advising students. Admission requires appointment to a teaching assistantship, research assistantship, or research fellowship.

**Degree Requirements.** The degree requires a minimum of 90 semester credit hours beyond the baccalaureate degree. The core curriculum consists of 30 semester credit hours of formal coursework, including elective courses that support the emphasis in neurobiology, and required teaching, research, and completion of the dissertation following advancement to candidacy. Enrollment in the Life Sciences Colloquium and Seminar in Life Sciences is 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 use up to 30 semester credit hours toward the degree provided the courses are comparable to core and elective courses.

**Program of Study**

A. Core curriculum (22 semester credit hours required):

- BIO 7113 Teaching in Life Sciences
- BIO 7121 Neurobiology Fundamentals: Neurochemistry
- BIO 7131 Neurobiology Fundamentals: Behavioral Neurobiology
- BIO 7141 Neurobiology Fundamentals: Cellular and Molecular Neurobiology
- BIO 7151 Neurobiology Fundamentals: Neurophysiology
- BIO 7161 Neurobiology Fundamentals: Computational Neurobiology
- BIO 7171 Neurobiology Fundamentals: Neuroanatomy
- BIO 7181 Neurobiology Fundamentals: Neuropharmacology
- BIO 7413 Research Ethics and Responsible Conduct in Research
- BIO 7513 Advanced Biochemistry

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BIO 7573 Experimental Techniques in the Life Sciences
BIO 7643 Cellular and Molecular Biology

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

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 Dean of Graduate Studies for final approval.

**Advancement to Candidacy.** Advancement to candidacy requires a student to complete University and program requirements and to pass written and oral qualifying examinations following completion of course requirements. The examination is administered by the Doctoral Studies Committee and is conducted by the Dissertation Committee as outlined below. No more than two attempts to pass qualifying examinations are allowed. Results of the written and oral examinations must be reported to the Doctoral Studies Committee and the Dean of Graduate Studies. Admission into the doctoral 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 is 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 Dean of Graduate Studies guides and critiques 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 conducts 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 Dean of Graduate Studies. Awarding of the degree is based on the approval of the Dissertation Committee, approved by the Dean of Graduate Studies. The Dean of Graduate Studies certifies the completion of all University-wide requirements.

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COURSE DESCRIPTIONS

BIOLOGY

(BIO)

5013 **Survey of Environmental Sciences**
(3-0) 3 hours credit. Prerequisite: Graduate standing.
An integrative examination of living and nonliving environmental systems.
A detailed study of interrelationships among plants, animals, and the environment, addressing the chemical, physical, and biological properties of living system, and the principles that drive their evolution.

5023 **Molecular and Genetic Bases of Living Systems**
(3-0) 3 hours credit. Prerequisite: Graduate standing.
A comprehensive survey of modern principles of quantitative, molecular, and cell biology. An integrated examination of the biochemical, biophysical, and genetic properties of procaryotic and eukaryotic cells and multicellular organisms.

5243 **Advanced Plant Ecology**
(3-0) 3 hours credit. Prerequisites: BIO 3283, BIO 3292, or consent of instructor.
A study of the major biomes of the world, including North America and Texas, and the factors that influence the development of these biomes. Special consideration is given to species interactions that lead to high and low density species.

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

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.

5503 Sensory Physiology
(3-0) 3 hours credit. Prerequisite: BIO 4433 or consent of instructor.
Principles of sensory physiology, including sensory transduction and central processing of sensory information in vertebrate and invertebrate species.

5523 Enzymes
(3-0) 3 hours credit. Prerequisite: BIO 3513 or an equivalent.
A study of enzyme structure and mechanism, inhibitors, cofactor, kinetics, and regulation.
5543 Pharmacology and Toxicology
(3-0) 3 hours credit. Prerequisites: BIO 3513, 3522, 3413, and 3422.
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
are examined.

5563 Biochemical Macromolecules
(3-0) 3 hours credit. Prerequisite: BIO 3513 or an equivalent.
Structure, function, and isolation of macromolecules. Emphasis is on nucleic
acids and proteins and their interactions.

5583 Neuropharmacology
(3-0) 3 hours credit. Prerequisites: Graduate standing in the life sciences.
A study of drugs that affect nervous tissue, specifically those affecting the
brain and autonomic nervous system.

5633 Cytodifferentiation
(3-0) 3 hours credit. Prerequisite: Graduate standing in the life sciences.
Detailed study of selected areas of developmental biology relating to cellular
der differentiation, including nuclear-cytoplasmic interactions, induction, and
reversibility of differentiation.

5743 Biochemical Virology
(3-0) 3 hours credit. Prerequisite: Graduate standing in the life sciences.
A detailed study of the diversity of viruses and biochemical mechanisms for
their replication.

5833 Membrane Structure and Function
(3-0) 3 hours credit. Prerequisite: BIO 3513 or an equivalent.
A study of the composition, organization, transport functions, and
permeability of natural and model membranes.

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 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.

6113 Advanced Plant Physiology
(3-0) 3 hours credit. Prerequisite: BIO 4603 or consent of instructor.
Principles of plant physiology and biochemistry, with particular emphasis
on plant hormones, nitrogen fixation, plant respiration, photosynthesis, and
current research work.

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
are considered.

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

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.

6823 **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 are included.
6873 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.

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).

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. 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.

6983 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.

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.

7121 Neurobiology Fundamentals: Neurochemistry
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
A survey of neurotransmission, emphasizing biochemical, neuroanalytical, and neuropathological aspects of major neurotransmitter systems in the central nervous system.

7131 Neurobiology Fundamentals: Behavioral Neurobiology
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
A survey of approaches to addressing the relation of brain function and structure to behavior, with an emphasis on recent studies utilizing novel neuroscientific methods used in conjunction with behavioral analysis.

7141 Neurobiology Fundamentals: Cellular and Molecular Neurobiology
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
The cellular and molecular organization and function of neurons will be reviewed. Both in vivo and in vitro molecular and cellular techniques used to study neurobiology will be covered.

7151 Neurobiology Fundamentals: Neurophysiology
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
An introduction to the basic principles underlying neuronal function, including membrane biophysics, action potentials, and synaptic transmission.

7161 Neurobiology Fundamentals: Computational Neurobiology
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
A survey of computational processing in single neurons, artificial neural networks, and biological neural systems.

7171 Neurobiology Fundamentals: Neuroanatomy
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.
An introduction to the anatomical and functional arrangements of the vertebrate central and peripheral nervous system, including the major sensory and motor circuitry.
7181  Neurobiology Fundamentals: Neuropharmacology  
(1-0) 1 hour credit. Prerequisite: Admission to the doctoral program in biology.  
An advanced review and discussion of the mechanisms of drug action in the nervous system, with an emphasis on synaptic function; neurotransmitter synthesis, release and metabolism, receptor and channel interactions, and the modulation of second messenger systems.

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.

7413  Research Ethics and Responsible Conduct in Research  
(3-0) 3 hours credit.  
A case-study approach to formal training in the responsible conduct of research. Includes areas of conflict of interest, responsible authorship, policies for handling misconduct, policies regarding the use of human and animal subjects, and data management.

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 include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Formerly BIO 5571-3.)

7643  Cellular and Molecular Biology  
(3-0) 3 hours credit. Prerequisite: BIO 3513 or consent of instructor.  
Structure of eucaryotic and proaryotic 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: mathematics, mathematics education, and statistics.

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

Degree Requirements. Degree candidates are required to successfully complete 36 semester credit hours.

A. All students, regardless of concentration, must complete the following 9 hours of coursework:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 5203</td>
<td>Theory of Functions of a Real Variable I</td>
</tr>
<tr>
<td>MAT 5283</td>
<td>Linear Algebra and Matrix Theory</td>
</tr>
<tr>
<td>STA 5503</td>
<td>Mathematical Statistics I</td>
</tr>
</tbody>
</table>

B. In addition, students must complete the required courses for one of the following concentrations:

Mathematics (12 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 5173</td>
<td>Algebra I</td>
</tr>
<tr>
<td>MAT 5223</td>
<td>Theory of Functions of a Complex Variable I</td>
</tr>
<tr>
<td>MAT 5403</td>
<td>Functional Analysis I</td>
</tr>
<tr>
<td>MAT 5603</td>
<td>Numerical Analysis</td>
</tr>
</tbody>
</table>

Mathematics Education (9 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 5023</td>
<td>Problem Solving Seminar</td>
</tr>
<tr>
<td>MAT 5033</td>
<td>Foundations and Fundamental Concepts of Mathematics</td>
</tr>
<tr>
<td>MAT 5043</td>
<td>Euclidean and Non-Euclidean Geometry</td>
</tr>
</tbody>
</table>

Statistics (9 semester credit hours):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>STA 5133</td>
<td>Data Analysis with Statistical Software</td>
</tr>
<tr>
<td>STA 5513</td>
<td>Mathematical Statistics II</td>
</tr>
<tr>
<td>STA 5713</td>
<td>Foundations of Linear Models</td>
</tr>
</tbody>
</table>

C. Students must either 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 in the Division of Mathematics and Statistics. Students pursuing the concentration in Mathematics Education must normally take an additional 12 semester credit hours of coursework chosen from eligible graduate courses in the division, and they may apply a maximum of 9 semester credit hours of graduate coursework from other disciplines as approved by the Graduate Advisor of Record. Students pursuing the concentration in Statistics must normally take an additional 12 semester credit hours of coursework chosen from eligible statistics graduate courses, with a minimum of 6 semester credit hours in 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.

E. Students are required to pass an advanced comprehensive examination or successfully defend their thesis research results.

More detailed information can be obtained from the Graduate Advisor of Record.

**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 algorithmic-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.

5033 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.

5043 **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.

5173 **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.

5203 **Theory of Functions of a Real Variable I**  
(3-0) 3 hours credit. Prerequisite: MAT 4223 or consent of instructor.  
Measure and integration theory.

5213 **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.

5223 **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.

5233 **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.

5243 **General Topology I**  
(3-0) 3 hours credit. Prerequisite: MAT 4273 or consent of instructor.  
Topological spaces, metric spaces, continua, and plane topology.

5253 **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.  

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.  

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 include boardwork, 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 lectures 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. Topics in applied statistics 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, JMP, S-Plus, and other popular
statistical software. Manipulation of data sets and production of reports and
graphs. Emphasis is on linear models and basic multivariate procedures.
Introduction to programming in the S-Plus language.

5213 Advanced Statistical Quality Control
(3-0) 3 hours credit. Prerequisite: EGR 5103 or consent of instructor.
Methods and techniques for process control, process and gage capability
analyses, inspection plans, American National Standards, and recent
advanced techniques. Use of statistical software including JMP. Tour of
manufacturing industry. Case studies in process control outgoing quality
and costs. A required project, assigned by a manufacturing company, must
be presented. This course is designed for technology managers and engineers
and may not be applied to a Master of Science degree in Statistics.

5233 Product and Manufacturing Reliability
(3-0) 3 hours credit. Prerequisite: EGR 5103 or consent of instructor.
Topics include product and manufacturing reliability from managerial,
engineering, and statistical perspectives. Emphasis on component and system
reliability estimation, testing, and demonstration. Advanced topics such as
accelerated life tests, Bayesian procedures, system availability, system
maintainability, and compliance with international standards are addressed.
Methods and theory are supported through data analytic packages such as
JMP, SAS, and S-Plus. This course is designed for technology managers
and engineers and may not be applied to a Master of Science degree in
Statistics.

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.

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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, multistage and double sampling, and bootstrap and other sampling plans.

5413 **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.

5503 **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.

5513 **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.

5643 **Stochastic Processes**  
(3-0) 3 hours credit. Prerequisite: STA 5503 or consent of instructor.  
Poisson processes, renewal theory, Markov chains, and Markov processes, including branching processes, ruin problems, birth and death processes, and Brownian motion. Application in queueing theory, analysis of algorithms, and molecular genetics are discussed.

5713 **Foundation of Linear Models**  
(3-0) 3 hours credit. Prerequisites: MAT 2233 and either STA 5103 or consent of instructor.  
G-inverses, multivariate normal, and distribution of quadratic forms; least squares estimation and the Gauss-Markov theorem; likelihood ratio tests for full-rank and less-than-full-rank models, including regression and analysis of variance models.

5723 **Theory and Application of Linear Models**  
(3-0) 3 hours credit. Prerequisite: STA 5713.  
Analysis of covariance, random effects, and mixed effects models; analysis of repeated measures. Emphasis on applications and use of statistical packages.

5803 **Process Control and Acceptance Sampling**  
(3-0) 3 hours credit. Prerequisite: STA 3523 or STA 5103 or consent of instructor.  
Introduction to statistical process control and product inspection plans. Topics include control charts by attributes and variables, special control charts, specification limits, process capability, and acceptance sampling plans by attributes and variables. Use of statistical software.
5813  **Applied Multivariate Statistics**  
(3-0) 3 hours credit. Prerequisites: MAT 2233 and either STA 5103 or consent of instructor.  
Principal components, factor analysis, cluster analysis, multidimensional scaling, discriminant analysis, multivariate normal distribution, estimation of mean vector and covariance matrix, Hotelling's $T^2$, and tests concerning covariance matrices.

5833  **Design and Analysis of Experiments**  
(3-0) 3 hours credit. Prerequisite: STA 3523, STA 5103, STA 5513, or consent of instructor.  
Introduction to experimental design and data analysis in scientific and engineering settings. Topics include one-factor experiments, randomized block designs, factorials, two- and three-level factorial and fractional factorial designs, nested and split-plot designs, response surface methods and Taguchi methods. Use of statistical software.

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  **Survival Analysis**  
(3-0) 3 hours credit. Prerequisite: STA 5513, 5103, or consent of instructor.  
This course covers topics in survival measures and lifetime distributions. A primary approach focuses on estimation and hypothesis testing regarding the parameters in these models. Advanced topics, such as Cox regression models and competing risk models, are presented from epidemiological and biomedical databases. Methods and theory are supported through analytic software such as SAS and S-Plus.

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.