Department of Mathematics

The Department of Mathematics offers Master of Science degrees in Applied Mathematics–Industrial Mathematics, Mathematics, and Mathematics Education.

- M.S. in Applied Mathematics–Industrial Mathematics (p. 1)
- M.S. in Mathematics (p. 1)
- M.S. in Mathematics Education (p. 2)

Master of Science Degree in Applied Mathematics–Industrial Mathematics

The Master of Science Degree in Applied Mathematics–Industrial Mathematics is designed to provide students the opportunity for advanced training in marketable areas of Applied Mathematics, using research to solve real-world problems in the field of Applied Mathematics, and with preparation for leadership positions in the field. In order to provide students with advanced training in marketable areas, 24 semester credit hours of graduate mathematics courses and 3 semester credit hours of a course in the Colleges of Sciences or Engineering are required. Research exposure to and experience with real-world problems will be provided by enrollment in AIM 6943 Internship and Research Project. This course introduces students to research problems in the field as well as the opportunities to solve a real-life problem in an industrial setting. Students will prepare for leadership positions in the field by taking two courses in communication, leadership, and/or basic business practices.

Program Admission Requirements

To be admitted to the degree program for the M.S. in Applied Mathematics–Industrial Mathematics, applicants must satisfy the University-wide requirements for admission to graduate programs. The applicant must have completed a bachelor’s degree in mathematics, science, engineering, or a related field and must have taken Calculus I, Calculus II, Linear Algebra, and an upper-division course in mathematics. The applicant must submit a résumé, scores from the Graduate Record Examination (GRE), and three letters of reference from qualified scientists, mathematicians, or supervisors that can certify their ability to pursue studies in applied mathematics at the Master's level.

Degree Requirements

Degree candidates are required to successfully complete 36 semester credit hours and meet University-wide degree requirements. Students admitted to the program must consult the Graduate Advisor of Record for their individual study plans and get approval before enrollment in each course.

Candidates for the degree must complete:

A. 6 semester credit hours of required courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIM 5113</td>
<td>Introduction to Industrial Mathematics</td>
</tr>
<tr>
<td>MAT 5283</td>
<td>Linear Algebra and Matrix Theory</td>
</tr>
</tbody>
</table>

B. Select 18 semester credit hours of the following:

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MAT 5203</td>
<td>Theory of Functions of a Real Variable I</td>
</tr>
<tr>
<td>MAT 5223</td>
<td>Theory of Functions of a Complex Variable I</td>
</tr>
<tr>
<td>MAT 5293</td>
<td>Numerical Linear Algebra</td>
</tr>
</tbody>
</table>

C. 3 semester credit hours of electives: Upon completion of 18 semester credit hours in mathematics, a student is eligible to enroll in advanced courses selected from disciplines in the Colleges of Sciences or Engineering.

D. 3 semester credit hours of Internship and Research Project: *

E. 6 semester credit hours selected from coursework in communications, leadership skills, and business principles such as:

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MGT 5003</td>
<td>Conceptual Foundations of Management</td>
</tr>
<tr>
<td>MGT 5043</td>
<td>Management and Behavior in Organizations</td>
</tr>
<tr>
<td>MGT 593</td>
<td>Leadership</td>
</tr>
</tbody>
</table>

Total Credit Hours: 36

* Internship and Research Project

Upon completion of 18 semester credit hours in mathematics, a student is eligible to enroll in AIM 6943 Internship and Research Project. The student must spend a semester in an industrial setting and must complete an internship-related project. To complete the internship-related project, the student will:

1. Submit either an employment letter from a company or a pre-internship proposal outlining the proposed work for approval by the student’s Supervising Professor.
2. Complete the proposed work after the internship has been completed.
3. Defend the project before the deadlines set forth by the University.

Students currently employed in industry may negotiate an alternative internship experience.

Master of Science Degree in Mathematics

Program Admission Requirements

In addition to satisfying the University-wide graduate admission requirements, a Bachelor of Arts or Bachelor of Science in Mathematics is highly recommended as preparation. However, exceptional applicants with a Bachelor’s degree in a closely related field may also be considered for admission. 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 should provide scores from the Graduate Record Examination (GRE). It is recommended that the applicant submit two letters of reference, preferably from those who can speak to the applicant’s mathematical abilities.

Degree Requirements

Degree candidates are required to successfully complete 36 semester credit hours in one of two concentrations, (1) Mathematics or (2) Applied Mathematics.

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MAT 5323</td>
<td>Mathematical Modeling</td>
</tr>
<tr>
<td>MAT 5603</td>
<td>Numerical Analysis</td>
</tr>
<tr>
<td>MAT 5613</td>
<td>Numerical Solutions of Differential Equations</td>
</tr>
<tr>
<td>MAT 5653</td>
<td>Differential Equations I</td>
</tr>
<tr>
<td>MAT 5673</td>
<td>Partial Differential Equations I</td>
</tr>
<tr>
<td>MAT 5973</td>
<td>Directed Research</td>
</tr>
<tr>
<td>MAT 5983</td>
<td>Topics in Applied Mathematics</td>
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<tr>
<td>MAT 6603</td>
<td>Optimization Techniques in Operations Research</td>
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<tr>
<td>AIM 6943</td>
<td>Internship and Research Project</td>
</tr>
<tr>
<td>MGT 593</td>
<td>Leadership</td>
</tr>
</tbody>
</table>
Degree candidates are required to successfully complete 36 semester credit hours.

A. Students must complete the following 9 hours of required coursework:

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<td>MAT 5203</td>
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<tr>
<td>MAT 5223</td>
<td>Theory of Functions of a Complex Variable I</td>
</tr>
<tr>
<td>MAT 5243</td>
<td>General Topology I</td>
</tr>
</tbody>
</table>

B. Students must complete 9 hours of required coursework for the selected concentration:

**Mathematics Concentration**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>MAT 5173</td>
<td>Algebra I</td>
</tr>
<tr>
<td>MAT 5283</td>
<td>Linear Algebra and Matrix Theory</td>
</tr>
<tr>
<td>MAT 5403</td>
<td>Functional Analysis I</td>
</tr>
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**Applied Mathematics Concentration**

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<tbody>
<tr>
<td>MAT 5293</td>
<td>Numerical Linear Algebra</td>
</tr>
<tr>
<td>MAT 5603</td>
<td>Numerical Analysis</td>
</tr>
<tr>
<td>MAT 5653</td>
<td>Differential Equations I</td>
</tr>
</tbody>
</table>

C. Students must normally take an additional 18 semester credit hours of coursework chosen from eligible graduate courses in the Department of Mathematics. Students may apply a maximum of 6 semester credit hours of graduate coursework from other disciplines as approved by the Graduate Advisor of Record. Undergraduate coursework taken for graduate credit must be approved by the Graduate Review Committee and may not exceed 6 hours of credit.

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

Total Credit Hours: 36

**Applied-Industrial Mathematics (AIM) Courses**

**AIM 5113. Introduction to Industrial Mathematics.** (3-0) 3 Credit Hours.
Prerequisites: MAT 1214, MAT 1224, and MAT 2233, or consent of instructor. The topics covered include quality control, Monte Carlo methods, linear programming, model fitting, frequency domain methods, difference and differential equations, and report writing. The course is not designed to substitute for any specialized course covering these topics in detail, but rather to survey their real-world applications.

**AIM 6943. Internship and Research Project.** (0-0) 3 Credit Hours.
Prerequisites: Completion of at least 18 semester credit hours of coursework in mathematics and consent of the student’s Supervising Professor; confirmation of approved internship. Provides students with hands-on experience in industrial mathematics or a related field in a professional environment. The research work may be either an extended project or a variety of shorter assignments. May be repeated for credit, but no more than 6 credit hours will apply toward the Master’s degree.

**Mathematics (MAT) Courses**

**MAT 5003. Modern Mathematics for Teachers.** (3-0) 3 Credit Hours.
A practical orientation concerned with the classroom uses of mathematics for teachers of K–12. This course may not be applied toward the Master of Science degree in Mathematics.

**MAT 5013. Computers for Mathematics Teachers.** (3-0) 3 Credit Hours.
A course for mathematics teachers on integrating the computer into the mathematics curriculum, with a focus on mathematical problem solving through the use of mathematical software packages. This course may not be applied to the Master of Science degree in Mathematics. (Credit cannot be earned for more than one of the following: MAT 5013, CS 5023 or CS 5063).

**MAT 5023. Problem-Solving Seminar.** (3-0) 3 Credit Hours.
Students will have the opportunity to engage in extensive experience and practice in solving mathematical problems.

**MAT 5033. Foundations and Fundamental Concepts of Mathematics.** (3-0) 3 Credit Hours.
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 may not be applied to the Master of Science degree in Mathematics without approval of the Graduate Advisor of Record and the Graduate Review Committee.

**MAT 5043. Euclidean and Non-Euclidean Geometry.** (3-0) 3 Credit Hours.
Topics will be selected from advanced Euclidean and non-Euclidean geometry, solid analytic geometry, and differential geometry.
MAT 5103. Introduction to Mathematical Analysis. (3-0) 3 Credit Hours.
Prerequisite: MAT 4213 or consent of instructor. Axiomatic construction of the reals, metric spaces, continuous functions, differentiation and integration, partial derivatives, and multiple integration. This course may not be applied to the Master of Science degree in Mathematics. (Credit cannot be earned for both MAT 5103 and MAT 5203).

MAT 5123. Introduction to Cryptography. (3-0) 3 Credit Hours.
Prerequisite: MAT 4213. Congruences and residue class rings, Fermat's Little Theorem, the Euler phi-function, the Chinese Remainder Theorem, complexity, symmetric-key cryptosystems, cyclic groups, primitive roots, discrete logarithms, one-way functions, public-key cryptosystems, digital signatures, finite fields, and elliptic curves.

MAT 5173. Algebra I. (3-0) 3 Credit Hours.
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.

MAT 5203. Theory of Functions of a Real Variable I. (3-0) 3 Credit Hours.
Prerequisite: MAT 4213 or consent of instructor. Measure and integration theory. (Credit cannot be earned for both MAT 5203 and MAT 5103).

MAT 5213. Theory of Functions of a Real Variable II. (3-0) 3 Credit Hours.
Prerequisite: MAT 5203. Further development of measure and integration theory, metric space topology, and elementary Banach space theory.

MAT 5223. Theory of Functions of a Complex Variable I. (3-0) 3 Credit Hours.
Prerequisite: MAT 3213 or MAT 4213. Complex integration, Cauchy's theorem, calculus of residues, and power series.

MAT 5233. Theory of Functions of a Complex Variable II. (3-0) 3 Credit Hours.
Prerequisite: MAT 5223. Infinite products, entire functions, Picard's theorem, Riemann mapping theorem, and functions of several complex variables.

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

MAT 5253. General Topology II. (3-0) 3 Credit Hours.
Prerequisite: MAT 5243. Topics may include: Metrizable topological spaces, function spaces, covering spaces, homotopy theory and fundamental groups, classification of surfaces, and others.

MAT 5263. Algebraic Topology. (3-0) 3 Credit Hours.
Prerequisite: MAT 4273 or MAT 5243. Fundamental ideas of algebraic topology, homotopy and simplicial complexes, fundamental group, covering spaces, and duality theorems.

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

MAT 5293. Numerical Linear Algebra. (3-0) 3 Credit Hours.
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).

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

MAT 5323. Mathematical Modeling. (3-0) 3 Credit Hours.
Prerequisite: MAT 3633 or equivalent. Techniques of mathematical modeling for applications, including ordinary and partial differential equations, stochastic models, discrete models and optimization, modeling error and uncertainty quantification.

MAT 5343. Differential Geometry. (3-0) 3 Credit Hours.
Prerequisite: MAT 5283 or equivalent. Multilinear algebra, differentiable manifolds, exterior differential forms, affine connections, Riemannian geometry, and curvature equations.

MAT 5353. Mathematics of Image Processing. (3-0) 3 Credit Hours.
Prerequisite: MAT 5613 or consent of instructor. Topics include image acquisition, denoising and enhancement, transformations, linear and nonlinear filters, image compression, segmentation and edge detection, morphology, and pattern recognition.

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

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

MAT 5603. Numerical Analysis. (3-0) 3 Credit Hours.
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).

MAT 5613. Numerical Solutions of Differential Equations. (3-0) 3 Credit Hours.
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.

MAT 5653. Differential Equations I. (3-0) 3 Credit Hours.
Prerequisites: MAT 3613 and MAT 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.

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

MAT 5673. Partial Differential Equations I. (3-0) 3 Credit Hours.
Prerequisite: MAT 3623, MAT 5663, or consent of instructor. Classical theory of initial value and boundary value problems for partial differential equations, including the heat equation, the wave equation and Laplace's equation.

MAT 5683. Partial Differential Equations II. (3-0) 3 Credit Hours.
Prerequisite: MAT 5673. Modern topics in partial differential equations.
MAT 5963. Introduction to Mathematics Education Research. (3-0) 3 Credit Hours.
Prerequisite: Consent of instructor. An introduction to important research and findings in mathematics education. Students will gain experience with interpreting education research and translating it into practice. Students will work on projects designed to help them investigate their own teaching practice. Topics include: mathematical learning theories, philosophical perspectives of mathematics, explorations of mathematical content, and research on student learning.

MAT 5973. Directed Research. (0-0) 3 Credit Hours.
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.

MAT 5983. Topics in Applied Mathematics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. In-depth study of current topics in applied mathematics. May be repeated for credit when topics vary.

MAT 6603. Optimization Techniques in Operations Research. (3-0) 3 Credit Hours.
Prerequisite: MAT 2214, MAT 2233, or consent of instructor. Analysis and application of optimization techniques in operations research. Emphasis on linear programming, nonlinear programming, and integer programming.

MAT 6953. Independent Study. (0-0) 3 Credit Hours.
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.

MAT 6961. Comprehensive Examination. (0-0) 1 Credit Hour.
Prerequisite: Approval of the appropriate graduate program committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination).

MAT 6963. Topics in Mathematics Education. (3-0) 3 Credit Hours.
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 topics vary but not more than 9 hours may be applied toward the Master's degree. This course may not be applied toward the Master of Science degree in Mathematics with a concentration in Mathematics.

MAT 6973. Special Problems. (3-0) 3 Credit Hours.
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.

MAT 6983. Master's Thesis. (0-0) 3 Credit Hours.
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.