Applied Mathematics and Statistics

Degrees Offered

- Master of Science (Applied Mathematics and Statistics)
- Doctor of Philosophy (Applied Mathematics and Statistics)

Program Description

The Department of Applied Mathematics and Statistics (AMS) at Colorado School of Mines prepares the next generation of mathematical and statistical scientists to be leaders in a world driven by increasingly complex technology and challenges. Our department is at the forefront of research in mathematical and statistical methods that are used to address the opportunities and challenges of the future. The AMS department offers two graduate degrees: A Master of Science in Applied Mathematics and Statistics and a Doctor of Philosophy in Applied Mathematics and Statistics. The master's program is designed to prepare candidates for careers in industry or government or for further study at the PhD level. The PhD program is sufficiently flexible to prepare candidates for careers in industry, government and academia. A course of study leading to the PhD degree can be designed either for students who have completed a master of science degree or for students with a bachelor of science degree.

The AMS department is also involved in the curriculum of three different interdisciplinary master's degree programs: Data Science, Operations Research with Engineering, and Quantitative Biosciences and Engineering. Please view Interdisciplinary Programs for more information on these programs.

Research within AMS is conducted in the following areas:

Computational and Applied Mathematics

- Deep Learning
- Differential and Integral Equations
- Dynamical Systems
- Geophysical and Environmental Applications
- High Performance Scientific Computing
- Mathematical Biology
- Meshfree Approximation Methods
- Multiscale Analysis and Simulation
- Numerical Methods for PDEs
- Optimal Control and Transport
- Wave Phenomena and Inverse Problems

Statistics

- Geophysical and Environmental Applications
- Methods for Massive Data Sets
- Spatial and Space-Time Processes
- Functional Data Analysis
- Inverse Problems
- Uncertainty Quantification

Master of Science Program Requirements

The master of science degree (non-thesis option) requires 30 credits of coursework. For both the Computational and Applied Mathematics and Statistics specialties, the curriculum structure consists of 1) a set of required courses, 2) a pair of MATH electives, and 3) general elective courses that serve to supplement the student's technical interests.

Specialty in Computational & Applied Mathematics

Required Courses

MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
SYGN502	INTRODUCTION TO RESEARCH ETHICS [*]	1.0
MATH589	APPLIED MATHEMATICS AND STATISTICS TEACHING SEMINAR [**]	1.0

 *Required only for students receiving federal support.
** Required only for students employed by the department as graduate teaching assistants or student instructor/lecturers.

Furthermore, students are required to complete two additional 500-level MATH courses.

Finally, the remaining 9 credits come from general elective courses and may be selected from any other graduate courses offered by the Department of Applied Mathematics and Statistics, except for specially designated service courses. Alternatively, up to 6 credits of elective courses may be taken in other departments on campus to satisfy this requirement.

Specialty in Statistics

Required Courses

MATH500	LINEAR VECTOR SPACES	3.0
MATH531	THEORY OF LINEAR MODELS	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
MATH560	INTRODUCTION TO KEY STATISTICAL LEARNING METHODS I	3.0
MATH589	APPLIED MATHEMATICS AND STATISTICS TEACHING SEMINAR [**]	1.0
SYGN502	INTRODUCTION TO RESEARCH ETHICS [*]	1.0

 *Required only for students receiving federal support.
** Required only for students employed by the department as graduate teaching assistants or student instructor/lecturers.

Furthermore, students are required to complete two additional 500-level MATH courses.

Finally, the remaining 9 credits come from general elective courses and may be selected from any other graduate courses offered by the Department of Applied Mathematics and Statistics, except for specially designated service courses. Alternatively, up to 6 credits of elective courses may be taken in other departments on campus to satisfy this requirement.

The Master of Science degree (thesis option) requires 30 credits of acceptable coursework and research, completion of a satisfactory thesis, and successful oral defense of this thesis. A minimum of 6 (and a maximum of 12) of the 30 credits must be designated for supervised research, which will be in lieu of electives. The coursework includes the required core curriculum for the chosen specialty described above.

Mines Combined Undergraduate/Graduate Degree Program

Students enrolled in Mines' combined undergraduate/graduate program may double count up to 6 credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with B- or better, not be substitutes for required coursework, and meet all other university, department, and program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

Doctor of Philosophy Program Requirements

The Doctor of Philosophy requires 72 credits beyond the bachelor's degree. At least 24 of these hours must be thesis hours. Doctoral students must pass the comprehensive examination (a qualifying examination and thesis proposal), complete a satisfactory thesis, and successfully defend their thesis.

Specialty in Computational & Applied Mathematics

Required Courses

MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
SYGN502	INTRODUCTION TO RESEARCH ETHICS [*]	1.0
MATH589	APPLIED MATHEMATICS AND STATISTICS TEACHING SEMINAR [**]	1.0
MATH588	INTRODUCTION TO QUANTITATIVE AND COMPUTATIONAL RESEARCH	1.0

 *Required only for students receiving federal support.
** Required only for students employed by the department as graduate teaching assistants or student instructor/lecturers.

Furthermore, students are required to complete two additional 500-level MATH courses.

Specialty in Statistics

Required Courses

MATH500	LINEAR VECTOR SPACES	3.0
MATH531	THEORY OF LINEAR MODELS	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
MATH560	INTRODUCTION TO KEY STATISTICAL LEARNING METHODS I	3.0

MATH588	INTRODUCTION TO QUANTITATIVE AND COMPUTATIONAL RESEARCH	1.0
MATH589	APPLIED MATHEMATICS AND STATISTICS TEACHING SEMINAR [**]	1.0
SYGN502	INTRODUCTION TO RESEARCH ETHICS [*]	1.0

 *Required only for students receiving federal support.
** Required only for students employed by the department as graduate teaching assistants or student instructor/lecturers.

Furthermore, students are required to complete two additional 500-level MATH courses.

Further information can be found on the Web at ams.mines.edu. This website provides an overview of the programs, requirements, and policies of the department.

Fields of Research:

Geophysical and Environmental Applications

Scientific Data Compression

Spatial and Space-Time Processes

Methods for Massive Data Sets

Functional Data Analysis

Inverse Problems in Statistics

Machine Learning

Uncertainty Quantification

Numerical Methods for PDEs

High-Performance Scientific Computing

Biological Fluid Dynamics

Meshfree Approximation Methods

PDEs and Kinetic Theory

Computational Hydrology

Mathematical Biology including:

Sleep and Circadian Rhythms

Blood Coagulation

Microorganism Motility

Epidemiology

Courses

MATH500. LINEAR VECTOR SPACES. 3.0 Semester Hrs.
(I) Finite dimensional vector spaces and subspaces: dimension, dual bases, annihilators. Linear transformations, matrices, projections, change of basis, similarity. Determinants, eigenvalues, multiplicity. Jordan form. Inner products and inner product spaces with orthogonality and completeness. Prerequisite: MATH301, MATH332. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- to be completed at a later date

MATH501. APPLIED ANALYSIS. 3.0 Semester Hrs.
(II) Fundamental theory and tools of applied analysis. Students in this course will be introduced to Banach, Hilbert, and Sobolev spaces; bounded and unbounded operators defined on such infinite dimensional spaces; and associated properties. These concepts will be applied to understand the properties of differential and integral operators occurring in mathematical models that govern various biological, physical and engineering processes. Prerequisites: MATH301 or equivalent.
Course Learning Outcomes

- 1) Show that a set or function is Lebesgue measurable. 2) Be able to describe Lp spaces and their properties. 3) Apply the Banach fixed point theorem. 4) Find the weak derivative of a function. 5) Solve problems involving metric spaces and their properties. 6) Solve problems involving fundamental definitions and theorems of Banach and Hilbert spaces.

MATH503. FUNCTIONAL ANALYSIS. 3.0 Semester Hrs.
(II) Properties of metric spaces, normed spaces and Banach spaces, inner product and Hilbert spaces. Fundamental theorems for normed and Banach spaces with applications. Orthogonality and orthonormal systems on Hilbert spaces with applications to approximation theory. Compact, bounded and unbounded operators. Duality, adjoint, self-adjoint, Hilbert-adjoint operators. Spectral analysis of linear operators. Applications to differential and integral equations. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- No change

MATH506. COMPLEX ANALYSIS II. 3.0 Semester Hrs.
(II) Analytic functions. Conformal mapping and applications. Analytic continuation.
Schlicht functions. Approximation theorems in the complex domain. Taught every other year. Prerequisite: MATH454. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- no change

MATH510. ORDINARY DIFFERENTIAL EQUATIONS AND DYNAMICAL SYSTEMS. 3.0 Semester Hrs.
(I) Topics to be covered: basic existence and uniqueness theory, systems of equations, stability, differential inequalities, Poincare-Bendixon theory, linearization. Other topics from: Hamiltonian systems, periodic and almost periodic systems, integral manifolds, Lyapunov functions, bifurcations, homoclinic points and chaos theory. Offered even years. 3 hours lecture; 3 semester hours. Prerequisite: MATH225 or MATH235 and MATH332 or MATH342 and MATH301.
Course Learning Outcomes

- no change

MATH514. APPLIED MATHEMATICS I. 3.0 Semester Hrs.
(II) The course focuses on the application of mathematical ideas and methods for solving problems in the applied sciences and engineering. Topics include dimensional analysis, regular and singular perturbation methods, boundary layer analysis, kinetics. Other topics may include variational calculus, boundary value problems and integral equations, and discrete models. Where applicable, there will be numerical approaches to complement the analytic ones.
Course Learning Outcomes

- No change

MATH515. APPLIED MATHEMATICS II. 3.0 Semester Hrs.
(II) The course focuses on the application of mathematical ideas and methods for solving problems in the applied sciences and engineering. Topics include non-numerical techniques for dealing with partial differential equations, wave phenomena, continuum mechanics, conservation laws, and transform methods.
Course Learning Outcomes

- no change

MATH530. INTRODUCTION TO STATISTICAL METHODS. 3.0 Semester Hrs.
(I,II) Review of probability, random variables, and discrete and continuous probability models. Descriptive statistics and graphical representations. General theory of Confidence intervals and hypothesis testing. Inferences for mean and variance of a single population. Inferences for means and variances for two populations. Inferences for proportions and count data. Prerequisites: MATH334.
Course Learning Outcomes

MATH531. THEORY OF LINEAR MODELS. 3.0 Semester Hrs.
(II) Statistical framework for estimation and inference based on multiple regression, including distribution theory for sums of squares statistics and estimators. Principles of analysis of variance (ANOVA), multiple comparisons, and experimental design. Also included are some relevant topics in multivariate analysis and asymptotic, large sample theory. Prerequisites. MATH332 and MATH534.

MATH532. SPATIAL STATISTICS. 3.0 Semester Hrs.
Modeling and analysis of data observed on a 2 or 3-dimensional surface. Random fields, variograms, covariances, stationarity, nonstationarity, kriging, simulation, Bayesian hierarchical models, spatial regression, SAR, CAR, QAR, and MA models, Geary/Moran indices, point processes, K-function, complete spatial randomness, homogeneous and inhomogeneous processes, marked point processes, spatio-temporal modeling. Course is offered every other year on even years. Prerequisites: MATH324 or equivalent.
Course Learning Outcomes

- no change

MATH533. TIME SERIES ANALYSIS AND ITS APPLICATIONS. 3.0 Semester Hrs.
Exploratory Analysis of Time Series, Stationary Time Series, Autocorrelation and Partial Autocorrelation, Autoregressive Moving Average (ARMA) Models, Forecasting, Estimation, ARIMA Models for Nonstationary Data, Multiplicative Seasonal ARIMA Models, The Spectral Density, Periodogram and Discrete Fourier Transform, Spectral Estimation, Multiple Series and Cross-Spectra, Linear Filters, Long Memory ARMA and Fractional Differencing, GARCH Models, Threshold Models, Regression with Autocorrelated Errors, Lagged Regression, Multivariate ARMAX Models. Prerequisites: MATH324, MATH335.
Course Learning Outcomes

- This course is designed to be useful for students facing the analysis of time-correlated data in the physical, biological, and social sciences.

MATH534. MATHEMATICAL STATISTICS I. 3.0 Semester Hrs.
(I) The basics of probability, discrete and continuous probability distributions, sampling distributions, order statistics, convergence in probability and in distribution, and basic limit theorems, including the

central limit theorem, are covered. Prerequisite: none. 3 hours lecture; 3 semester hours.

MATH535. MATHEMATICAL STATISTICS II. 3.0 Semester Hrs.
(II) The basics of hypothesis testing using likelihood ratios, point and interval estimation, consistency, efficiency, sufficient statistics, and some nonparametric methods are presented. Prerequisite: MATH534 or equivalent. 3 hours lecture; 3 semester hours.

MATH536. ADVANCED STATISTICAL MODELING. 3.0 Semester Hrs.
(II) Modern extensions of the standard linear model for analyzing data. Topics include generalized linear models, generalized additive models, mixed effects models, and resampling methods. Offered every two years on odd years. 3 hours lecture; 3 semester hours. Prerequisite: MATH335, MATH324.
Course Learning Outcomes

- no change

MATH537. MULTIVARIATE ANALYSIS. 3.0 Semester Hrs.
(I) Introduction to applied multivariate representations of data for use in data analysis. Topics include introduction to multivariate distributions; methods for data reduction, such as principal components; hierarchical and model-based clustering methods; factor analysis; canonical correlation analysis; multidimensional scaling; and multivariate hypothesis testing.

MATH538. STOCHASTIC MODELS. 3.0 Semester Hrs.
(II) An introduction to the mathematical principles of stochastic processes. Discrete- and continuous-time Markov processes, Poisson processes, Brownian motion. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- no change

MATH539. SURVIVAL ANALYSIS. 3.0 Semester Hrs.
(I) Basic theory and practice of survival analysis. Topics include survival and hazard functions, censoring and truncation, parametric and non-parametric inference, the proportional hazards model, model diagnostics. Offered on odd years. Prerequisite: MATH335, MATH535. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- no change

MATH540. PARALLEL SCIENTIFIC COMPUTING. 3.0 Semester Hrs.
This course is designed to facilitate students' learning of high-performance computing concepts and techniques to efficiently perform large-scale mathematical modelling and data analysis using modern high-performance architectures (e.g. multi-core processors, multiple processors, and/or accelerators). Emphasis will be placed on analysis and implementation of various scientific computing algorithms in high-level languages using their interfaces for parallel or accelerated computing. Use of scripting to manage HPC workflows is included. Additional emphasis will be placed on design of parallel algorithms and implementation optimization in assignments. Prerequisites: MATH307 and CSCI200.
Course Learning Outcomes

- no change

MATH547. SCIENTIFIC VISUALIZATION. 3.0 Semester Hrs.
Equivalent with CSCI547,
Scientific visualization uses computer graphics to create visual images which aid in understanding of complex, often massive numerical representation of scientific concepts or results. The main focus of this course is on techniques applicable to spatial data such as scalar, vector and tensor fields. Topics include volume rendering, texture based methods for vector and tensor field visualization, and scalar and vector field topology. Students will learn about modern visualization techniques by reading and discussing research papers and implementing one of the algorithms described in the literature.

MATH550. NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I) Numerical methods for solving partial differential equations. Explicit and implicit finite difference methods; stability, convergence, and consistency. Alternating direction implicit (ADI) methods. Weighted residual and finite element methods. Prerequisites: MATH225 or MATH235 and MATH332 or MATH342.

MATH551. COMPUTATIONAL LINEAR ALGEBRA. 3.0 Semester Hrs.
(II) Numerical analysis of algorithms for solving linear systems of equations, least squares methods, the symmetric eigenproblem, singular value decomposition, conjugate gradient iteration. Modification of algorithms to fit the architecture. Error analysis, existing software packages. 3 hours lecture; 3 semester hours. Prerequisite: MATH332, MATH 307.

MATH552. KERNEL-BASED APPROXIMATION METHODS. 3.0 Semester Hrs.
Positive definite kernels play an important role in many different areas of mathematics, science and engineering. We put these kernels into perspective, both historically, as well as scientifically via connections to related fields such as analysis, approximation theory, the theory of integral equations, mathematical physics, probability theory and statistics, geostatistics, statistical or machine learning, and various kinds of engineering or physics applications. None of these fields is given a thorough theoretical treatment. Instead, these topics are presented via their relation to positive definite kernels. Prerequisite: Graduate level mathematical maturity and confidence to build on elements from (computational) linear algebra, functional analysis, and Gaussian processes, such as eigenvalues, eigenfunctions, orthogonality, change of basis, Sturm-Liouville theory, Green's kernels, maximum likelihood estimation, Bayesian statistics, and convex optimization.
Course Learning Outcomes

- This course is designed to be useful for students interested in fitting multidimensional data (as arises, for example in many machine learning tasks) or numerically solving partial differential equations.

MATH557. INTEGRAL EQUATIONS. 3.0 Semester Hrs.
This is an introductory course on the theory and applications of integral equations. Abel, Fredholm and Volterra equations. Fredholm theory: small kernels, separable kernels, iteration, connections with linear algebra and Sturm-Liouville problems. Applications to boundary-value problems for Laplace's equation and other partial differential equations. Offered even years. Prerequisite: MATH332 or MATH342 and MATH455. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- no change

MATH559. ASYMPTOTICS. 3.0 Semester Hrs.
Equivalent with MATH459,
(I) Exact methods for solving mathematical problems are not always available: approximate methods must be developed. Often, problems involve small parameters, and this can be exploited so as to derive approximations: these are known as asymptotic approximations. Many

techniques for constructing asymptotic approximations have been devised. The course develops such approximations for algebraic problems, the evaluation of integrals, and the solutions of differential equations. Emphasis is placed on effective methods and, where possible, rigorous analysis. Prerequisites: Calculus and ordinary differential equations. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Use asymptotic methods to solve algebraic problems
- 2. Use asymptotic methods to estimate integrals
- 3. Use asymptotic methods to solve differential equations.

MATH560. INTRODUCTION TO KEY STATISTICAL LEARNING METHODS I. 3.0 Semester Hrs.
Equivalent with DSCI560,
Part one of a two-course series introducing statistical learning methods with a focus on conceptual understanding and practical applications. Methods covered will include Introduction to Statistical Learning, Linear Regression, Cross validation, Basis Expansions, Regularization, Non linear Models, Model Assessment and Selection. Prerequisite: MATH335 or MATH530 or DSCI530.
Course Learning Outcomes

- Understand what statistical learning is, how it is done and how it relates to real-world problems.
- Understand the concepts, assumptions and applicability of linear regression and gain the practical skills to be able to apply regression analysis to real-world data.
- Understand the concepts, assumptions and applicability of classification and gain the practical skills to be able to apply classification analysis to real-world data.
- Understand what resampling methods are, how they work and in which situations they can be used. Apply resampling methods to real-world problems.
- Understand what basis expansions are, how they work and in which situations they can be applied. Address real-world problems with basis expansion solutions.
- Understand what regularization methods are, why they can be useful and how to apply them in the context of regression and classification problems.
- Gain knowledge of multiple ways to diagnose and assess statistical models and how to select among different models.

MATH561. INTRODUCTION TO KEY STATISTICAL LEARNING METHODS II. 3.0 Semester Hrs.
Part two of a two course series introducing statistical learning methods with a focus on conceptual understanding and practical applications. Methods covered will include Classification, Bootstrap, Tree-based Methods, Support Vector Machines, Unsupervised Learning. Prerequisite: MATH560 or DSCI560.
Course Learning Outcomes

- Gain knowledge of a variety of nonlinear modeling approaches including polynomial regression, regression splines, smoothing splines, local regression and generalized additive models. Understand when to apply these methods and gain practical knowledge doing so with real-world data.
- Gain knowledge of tree-based approaches, including regression and classification trees, bagging, random forests, and boosting. Be able to compare them to linear models and know when to apply them and do so with real-world data.

- Know what support vector machines are, when to apply them and how they compare to other classification methods. Test them with real-world data for two and more classes.
- Understand the conceptual basis of neural networks, for which types of problems they are useful and what potential drawbacks are. Build a neural network for real-world data.
- Gain an overview of unsupervised methods including Principal Components Analysis and different clustering methods. Apply these methods to solve real-world problems.

MATH570. MATHEMATICAL MODELING OF SPATIAL PROCESSES IN BIOLOGY. 3.0 Semester Hrs.
(II) This course is an introduction to mathematical modeling of spatial processes in biology. The emphasis is on partial differential equation models from a diverse set of biological topics such as cellular homeostasis, muscle dynamics, neural dynamics, calcium handling, epidemiology, and chemotaxis. We will survey a variety of models and analyze their results in the context of the biology. Mathematically, we will examine the diffusion equation, advection equation, and combinations of the two that include reactions. There will be a significant computational component to the course including bi-weekly computational labs; students will solve the model equations and perform computations using MATLAB.
Course Learning Outcomes

- 1. Describe classical spatial-temporal models in mathematical biology including diffusion-reaction, advection-reaction, and advection-diffusion-reaction
- 2. Derive partial differential equations models for spatial-temporal phenomena
- 3. Implement analytical and numerical techniques to solve and analyze spatial-temporal models
- 4. Assimilate current literature, extend it in a final project that advances the field, and communicate results professionally and effectively

MATH572. MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE. 3.0 Semester Hrs.
(II) This course will focus on mathematical and computational techniques applied to neuroscience. Topics will include nonlinear dynamics, hysteresis, the cable equation, and representative models such as Wilson-Cowan, Hodgkin-Huxley, and FitzHugh-Nagumo. Applications will be motivated by student interests. In addition to building basic skills in applied math, students will gain insight into how mathematical sciences can be used to model and solve problems in neuroscience; develop a variety of strategies (computational, theoretical, etc.) with which to approach novel mathematical situations; and hone skills for communicating mathematical ideas precisely and concisely in an interdisciplinary context. In addition, the strong computational component of this course will help students to develop computer programming skills and apply appropriate technological tools to solve mathematical problems. Prerequisite: MATH331. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Describe the classical models of mathematical neuroscience including Hodgkin-Huxley, Wilson-Cowan, and FitzHugh-Nagumo
- Implement analytical and numerical techniques to analyze models at different spatial and temporal scales
- Apply concepts from nonlinear dynamics including phase plane analysis, bifurcation theory, and model reduction techniques to analyze models in neuroscience

- Assimilate current literature, extend it in a final project that advances the field, and communicate results professionally and effectively

MATH582. STATISTICS PRACTICUM. 3.0 Semester Hrs.
(II) This is the capstone course in the Statistics Option. The main objective is to apply statistical knowledge and skills to a data analysis problem, which will vary by semester. Students will gain experience in problem-solving; working in a team; presentation skills (both orally and written); and thinking independently. 3 hours lecture and discussion; 3 semester hours. Prerequisite: MATH 201 or 530 and MATH 324 or 531.

MATH588. INTRODUCTION TO QUANTITATIVE AND COMPUTATIONAL RESEARCH. 1.0 Semester Hr.
Students will be expected to use applied mathematics and statistics principles to critically analyze research results in published literature and place them in the context of related literature. Skills to be developed and discussed include critical review of the literature and oral defense of these reviews.
Course Learning Outcomes

- Critically analyze and evaluate research articles in applied mathematics and statistics
- Develop written syntheses that interpret, compare, and contrast multiple studies
- Effectively communicate these syntheses in the form of oral presentations
- Identify and describe effective communication styles in both research articles and oral presentations
- Identify knowledge gaps based on a synthesis of research articles and formulate new research questions/directions/applications

MATH589. APPLIED MATHEMATICS AND STATISTICS TEACHING SEMINAR. 1.0 Semester Hr.
(I) An introduction to teaching issues and techniques within the AMS department. Weekly, discussion-based seminars will cover practical issues such as lesson planning, grading, and test writing. Issues specific to the AMS core courses will be included. 1 hour lecture; 1.0 semester hour.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.

MATH598. SPECIAL TOPICS. 0-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

MATH691. GRADUATE SEMINAR. 1.0 Semester Hr.
(I) Presentation of latest research results by guest lecturers, staff, and advanced students. Prerequisite: none. 1 hour seminar; 1 semester hour. Repeatable for credit to a maximum of 12 hours.

MATH692. GRADUATE SEMINAR. 1.0 Semester Hr.
Equivalent with CSCI692,
(II) Presentation of latest research results by guest lecturers, staff, and advanced students. Prerequisite: none. 1 hour seminar; 1 semester hour. Repeatable for credit to a maximum of 12 hours.

MATH693. WAVE PHENOMENA SEMINAR. 1.0 Semester Hr.
(I, II) Students will probe a range of current methodologies and issues in seismic data processing, with emphasis on under lying assumptions, implications of these assumptions, and implications that would follow from use of alternative assumptions. Such analysis should provide seed topics for ongoing and subsequent research. Topic areas include: Statistics estimation and compensation, deconvolution, multiple suppression, suppression of other noises, wavelet estimation, imaging and inversion, extraction of stratigraphic and lithologic information, and correlation of surface and borehole seismic data with well log data. Prerequisite: none. 1 hour seminar; 1 semester hour.

MATH698. SPECIAL TOPICS. 0-6 Semester Hr.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MATH699. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

MATH707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) GRADUATE THESIS/DISSERTATION RESEARCH CREDIT Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.

Department Head

G. Gustave Greivel, Teaching Professor

Professors

Greg Fasshauer

Mahadevan Ganesh

Paul A. Martin

Doug Nychka

Stephen Pankavich

Associate Professors

Soutir Bandopadhyay

Cecilia Diniz Behn

Dorit Hammerling

Luis Tenorio

Assistant professors

Eileen Martin

Daniel McKenzie

Brennan Sprinkle

Samy Wu Fung

Teaching Professors

Terry Bridgman

Debra Carney

Holly Eklund

Mike Mikucki

Mike Nicholas

Jennifer Strong

Scott Strong

Rebecca Swanson

Teaching Associate Professor

Ashlyn Munson

Teaching Assistant Professors

John Griesmer

Nathan Lenssen

Daisy Philtron

Emeriti Professors

William R. Astle

Bernard Bialecki

Norman Bleistein

Ardel J. Boes

Austin R. Brown

John A. DeSanto

Graeme Fairweather

Raymond R. Gutzman

Frank G. Hagin

Willy Hereman

Donald C.B. Marsh

William Navidi

Steven Pruess

Emeriti Associate Professors

Barbara B. Bath

Ruth Maurer