Mathematics and Statistics

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Chongsheng Cao, *Professor*
Zhenmin Chen, *Professor (In Memoriam)*
Zhongxue Chen, *Professor*
Michael Davidson, *Assistant Teaching Professor*
Laura De Carli, *Professor*
Tedi Draghici, *Associate Professor*
Ian Dryden, *Professor*
Julian Edward, *Professor*
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Kathleen Guy, *Associate Teaching Professor*
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Jerry Hower, *Associate Teaching Professor*
Kai Huang, *Associate Professor*
George Kafkoulis, *Associate Professor*
Golam Kibria, *Professor*
Solange Kouemou, *Teaching Professor*
Mark Leckband, *Professor Emeritus*
Thomas Leness, *Professor*
Bao Qin Li, *Professor*
Xiaosheng Li, *Associate Professor*
Dane McGuckian, *Teaching Professor Advisor and Undergraduate Director (Statistics)*
Lakshmy Menon, *Associate Teaching Professor*
Idris Mercer, *Assistant Teaching Professor*
Roneet Merkin, *Associate Teaching Professor*
Abdelhamid Meziani, *Professor*
Jie Mi, *Professor*
Ada Monserrat, *Associate Teaching Professor*
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Sergio Perez, *Associate Teaching Professor*
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Laura Reisert, *Associate Teaching Professor*
Alireza Rostamian, *Teaching Professor*
Svetlana Roudenko, *Professor and Graduate Program Director*
Philippe Rukimbira, *Professor*
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Robert Storfer, *Associate Teaching Professor*
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Theodore Tachim Medjo, *Professor*
Enrique Villamor, *Professor*
Wei Wang, *Associate Professor*
Zhongming Wang, *Associate Professor*
Anna Wlodarczyk, *Teaching Professor*
Wensong Wu, *Associate Professor*
Yi Zhi Yang, *Associate Teaching Professor*
Mirroslav Yotov, *Teaching Professor*
Hassan Zahedi-Jasbi, *Associate Professor*
John Zweibel, *Associate Professor, Advisor and Undergraduate Director*

Master of Science in Mathematical Sciences

Admission Requirements

The following are in addition to the University's graduate admission requirements:

1. Bachelor's degree in mathematics, applied mathematics or mathematical sciences from an accredited university or college. A bachelor's degree in some other discipline is also acceptable provided the applicant has sufficient mathematics background. The following courses (or equivalent courses) are required for those whose bachelor's degrees are not in mathematics, applied mathematics or mathematical sciences: Advanced Calculus, Linear Algebra, Complex Variables and Algebraic Structures.
2. A 'B' average or higher in upper division mathematics courses.
3. Graduate Record Examination (GRE) taken within the past five years. At least 151 on the quantitative portion of the GRE, or an earned graduate degree from an accredited institution and the approval of the department. Risk Analysis Management Track applicants are allowed to use Graduate Management Admission Test (GMAT) to meet the admission requirement instead of GRE. The minimum required GMAT total score is 500.
4. Three letters of recommendation concerning the candidate's achievement and potential, from persons familiar with the candidate's previous academic performance.
5. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required.
6. Approval of the Graduate Committee.

Option 1

The student must complete a minimum of 24 semester hours of graduate course work. This course work must include 5 courses from the following two lists, with at least 2 from each list.

List A:

MAA 6406	Complex Analysis	3
MAA 6616	Real Analysis	3
MAP 5316	Ordinary Differential Equations	3
MAS 5311	Graduate Algebra	3
MAS 5312	Galois Theory	3
MHF 5107	Graduate Set Theory	3
MHF 5306	Graduate Mathematical Logic	3
MHF 5325	Theory of Recursive Functions	3
MTG 5326	Introduction to Algebraic Topology	3
MAP 5415	Introduction to Fourier Analysis	3

List B:

MAD 5405	Numerical Methods	3
MAP 5236	Mathematical Techniques of Operations Research	3
MAP 6326	Partial Differential Equations	3
MAP 5406	Introduction to Functional and Applied Analysis	3
MAS 5145	Applied Linear Algebra	3
MAP 5467	Stochastic Differential Equations	3
STA 5446	Probability Theory I	3
STA 5447	Probability Theory II	3

Electives

The remaining 9 hours of course work will be used to enhance a coherent program of study best suited to the student's needs and interest. This requires the prior approval of the Graduate Committee and may be done in one or a combination of the following ways: a) Further work from lists A and B. b) A maximum of 2 courses of independent study, taken with Mathematical Sciences faculty. c) Graduate level course work in Engineering, Physics or Statistics.

Master's Project

The student will complete his or her graduation requirements by writing an expository paper under the direction of a faculty member. The student may earn six credit hours (MAT 5970 Master's Research) in preparing the project. Successful completion of the Master's project requires a grade of 'B' or higher, as well as approval of a committee consisting of three mathematics faculty (including the director).

Remarks: The course work must be completed with a 3.0 or higher Grade Point Average (GPA) and a grade of 'C' or higher in each course. A maximum of six graduate semester hours may be transferred into the program from outside the University, subject to the approval of the Graduate Committee. A total of 30 credit hours is required for graduation.

Option 2

This course work must include 7 courses from List A and List B in Option 1, with at least 3 courses from each list.

Electives

Same as in Option 1.

Option 2 has no Master's Project requirement

Remarks: The course work must be completed with a 3.0 or higher Grade Point Average (GPA) and a grade of 'C' or higher in each course. A maximum of six graduate semester hours may be transferred into the program from outside the University, subject to the approval of the Graduate Committee. A total of 30 credit hours is required for graduation.

Risk Analysis and Management Track

This track will consist of 12 one-semester three credit graduate courses. The degree can be completed in 12 months (express track) or two years (normal track). Students must complete requirement in six years.

Admission Requirements

Admission requires a Bachelor's in Mathematics or related fields. In addition, applicants must satisfy conditions 3 through 5 in the admission requirements for our Master of Science in Mathematical Sciences, and have a GPA of at least 3.0 in undergraduate studies. Admission to the program requires applicants to have a firm grasp of mathematics at a high undergraduate level. This means calculus through multivariable calculus, linear algebra and differential equations. Knowledge in probability, statistics, computer programming, economics, or finance is recommended but not required. A student with promise but lacking prerequisites may be admitted but required to take one or more preparatory courses during their first semester.

Degree Requirements

The track in Risk Analysis and Management (RAM for short) requires 36 credits. The student must take 12 graduate credits, 3 credits each.

Course Requirements

Required courses (8):

MAP 6631	Introduction to Risk Analysis and Management
MAP 6635	Risk Analysis and Management I
MAP 6636	Risk Analysis and Management II
MAD 5405	Numerical Methods in Finance
MAP 6218	Stochastic Calculus
MAP 5117	Mathematics and Statistics Modeling in Finance
MAP 6632	PDE in Risk Analysis and Management
CAP 5768	Introduction to Data Science

Elective courses (choose 4):

MAA 6616	Real Analysis
MAP 5204	Optimization and Linear Algebra
MAP 6637	Risk Analysis and Management III
ECO 7429	Topics in Econometrics
FIN 6426	Financial Management Policies
FIN 6428	Corporate finance
FIN 6487	Financial Risk Management
FIN 6515	Security Analysis
FIN 6538	Financial Futures and Fixed Income Derivatives
CAP 5610	Introduction to Machine Learning
CAP 5771	Principles of data mining
CAP 6619	Advanced topics in machine learning
ECP 6305	Advanced environmental economics
ENV 6614	Environmental Risk Management
STA 6326	Mathematical Statistics I

Elective courses are not exhaustive, students interested in other courses are encouraged to pursue them upon approval by graduate program advisor.

Combined BS in Mathematics/MS in Mathematical Sciences Degree Pathway

This pathway will allow strong students in mathematics to complete a bachelor's degree and a master's degree in 5 years rather than the usual six. A minimum of 140 credits are required for graduation with both the bachelor's and the master's degree. In addition to fulfilling the requirements for the Bachelor's degree in mathematics, these 140 credits include 30 graduate credits required for the Master's of Science in Mathematical Sciences. A maximum of ten (10) graduate mathematics credits can be concurrently used toward the bachelor's and master's degrees.

To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

1. Current enrollment in a Bachelor's degree program in mathematics.
2. Current overall GPA of at least 3.2 and GPA of at least 3.2 in upper division courses.
3. Completion of 75 undergraduate credit-hours.
4. (Verbal and Quantitative) GRE scores with a minimum of 151 in the quantitative portion before entering the MS phase of the program.
5. Approval of the graduate committee.

Completion Requirements

Year 1 and 2:

MAC 2311	Calculus I
MAC 2312	Calculus II
MAC 2313	Calculus III
MAS 3105	Linear Algebra
MAP 2302	Ordinary Differential Equations

Year 3

Fall

MAA 3200	Introduction to Advanced Mathematics
STA 4321	Introduction to Mathematical Sciences I

One course from List 1 or 2

Spring

MAA 4211	Advanced Calculus
MAS 4301	Algebraic Structures

One course from List 1 or 2

Summer

One course from List 1 or 2 and 1 graduate course

Year 4

Fall

MAA 6616 Real Analysis

One course from List 1 or 2

Senior Seminar (1 credit)

Spring

One graduate course

Two courses from List 1 or 2

Summer

Three graduate credits

Year 5

Fall

Nine graduate credits

Spring

Nine graduate credits

The graduate courses distribution should follow catalog descriptions of the master's program requirements. Students must take at least 3 courses from List 1 and at least 3 courses from List 2. The balance of the 140 semester hours required for graduation may be chosen from any courses in the university, a minimum of six (6) of these should be at the upper division level or higher.

List 1

MAD 4203	Introduction to Combinatorics	3
MAA 4402	Complex Variables	3
MTG 3212	College Geometry	3
MAS 4203	Number Theory	3
MAA 4212	Topics in Advanced Calculus	3
MAS 4302	Topics in Algebraic Structures	3
MTG 4302	Topology	3

List 2

MAP 4401	Advanced Differential Equations	3
MAD 3305	Graph Theory	3
MAP 3103	Mathematical Modeling	3
STA 4322	Mathematical Statistics II	3
MAD 3401	Numerical Analysis	3
MHF 4302	Mathematical Logic	3
MHF 4102	Axiomatic Set Theory	3

Doctor of Philosophy in Applied Mathematical Sciences

Admission Requirements

1. Have either a bachelor's or a graduate degree in Mathematics or another quantitative field
2. Have a GPA of at least 3.0 in the bachelor's or Masters' degree
3. GRE test results
4. Official transcripts and least three letters of recommendation.
5. Have received approval of the departmental graduate committee
6. Foreign student whose native language is not English must obtain a score of 80 or higher on the TOEFL iBT (this corresponds to 550 on the old TOEFL test) or 6.3 overall on the IELTS. The University Graduate School has a list of countries that are exempt from this requirement.

Required Core Courses

MAA 6616	Real Analysis	3
MAA 6406	Complex Analysis	3
MAD 5405	Numerical Methods	3
MAP 5316	Ordinary Differential Equations	3
MAP 6326	Partial Differential Equations	3
MAS 5145	Applied Linear Algebra	3
MAP 5255	Scientific Computations	3
MAT 5921	Training in Mathematical Expositions	0

Required Other Courses

MAT 7981	Ph.D. Dissertation	15

Thesis Preparatory Courses

MAA 6506	Functional Analysis	3
MAP 6217	Calculus of Variations	3
MAD 6409	Numerical Methods II	3
MAD 7408	Topics in Numerical Analysis	3
MAP 5415	Introduction to Fourier Analysis	3
MAP 6357	Partial Differential Equations II	3
MAP 7359	Topics in Partial Differential Equations	3
MAP 6218	Stochastic Calculus	3
MAP 5467	Stochastic Differential Equations	3
STA 5446	Probability Theory I	3
STA 5447	Probability Theory II	3
STA 6807	Queuing and Statistical Models	3

Thesis Research Courses

MAT 7908	Independent Study	1-3
MAT 7917	Research Seminar	3
MAT 7980	Dissertation Research	1-9

Course Requirements

The Doctor in Applied Mathematics degree will be made up of the 8 core courses, a minimum of 15 credit hours must be of Ph.D. dissertation course, at least 4 courses (for a subtotal of at least 12 credits) from the thesis preparatory courses list. The remaining 27 credits of the required 75 may be filled by courses from:

1. Any courses from the thesis preparatory courses which are not counted as the four courses. Above, or thesis research courses, or other 6XXX/7XXX courses from the departmental catalog.
2. Courses of level 5000 or higher from Computer Science, Statistics, Physics, Economics, or Engineering approved by the Graduate Committee.
3. If a student has a co-advisor from another department, then at least 6 credits must be taken from the other department.

Graduation Requirements

1. Completing a total of 75 credit hours of course
2. A grade of 'B' or higher in all required core courses and a cumulative average of 3.0 or higher in the 75 credits of coursework.
3. Successful completion of the written portion of the Qualifying Exam. This examination is designed primarily to make sure the student has suitable background knowledge to conduct research in his/her chosen area. The student must pass the written Qualifying Exam by the end of the fifth semester (excluding summers) in the program. Two attempts are permitted. Any exception needs to be approved by the Graduate Committee. The student chooses any two of the following six areas of the exams: (1) Analysis (including both real analysis and complex analysis); (2) Differential Equations (including both Ordinary Differential Equations and Partial Differential Equations); (3) Numerical Analysis; (4) Mathematical Statistics; (5) Algebra (Graduate Algebra and Applied Linear Algebra); (6) Geometry/Topology (Introduction to Algebraic Topology and Differential Geometry).
4. Choosing advisor(s). The student will choose a faculty from the Department of Mathematics and Statistics as their dissertation advisor. A co-advisor could be selected from within the department or from outside.
5. Successful completion of the oral portion of the Qualifying Exam. The student will present and defend an oral examination. The purpose of this exam is to verify that the candidate has chosen a suitable topic for dissertation research and to evaluate the candidate's ability to conduct such research. The student will normally take the oral examination after completion of the core requirements and the written portion of the Qualifying Exam. The oral examination will be conducted by a panel of math faculty including the student's advisor(s). During the oral examination, the candidate presents his/her accomplished and proposed research and answers questions from the panel and others in the audience.
6. Upon completion of the required core courses and passing both portions of the Qualifying Exam, the student can advance to Candidacy.

Dissertation Requirements

1. The student will assemble a Dissertation Committee of at least four faculty members [including advisor(s)], three of whom will be from the Department of Mathematics and Statistics.
2. Submission and defense of a dissertation based upon original research in mathematical science. A dissertation is required of all candidates for the PhD degree and must conform to the format outlined in the Regulations for Thesis and Dissertation Preparation Manual available to students online from the FIU Graduate School.
3. After submission of the dissertation and completion of all other required work for the PhD degree, the candidate will be given a final oral thesis defense examination by the Dissertation Committee. Successful completion of all of these steps will culminate in the granting of the PhD degree.

Master of Science in Statistics

The Master of Science in Statistics at Florida International University is primarily an applied statistics program. It offers a balance of statistical theory, statistical methodology, and optionally, an area application concentration. The program offers a thesis option and a non-thesis option. Regardless of the concentration or thesis option, the program requires a total of 36 credit-hours as follows: six core courses (18 hours), four elective courses or an area of concentration (12 hours), and either a thesis (6 hours) or two additional elective courses (6 hours) and a comprehensive examination.

Admission Requirements

To be admitted into the program, applicants must meet the university's graduate admission requirements (see Office of Graduate Admissions in this catalog), GRE scores are required. However, the GRE requirement can be replaced by any nationally and internationally comparable exams that are approved by the Department's Graduate Committee, such as GEE (Graduate Entrance Exam). If an applicant has an earned graduate degree from an accredited US institution, the Department may waive the GRE requirement. All the applicants must also meet the following departmental requirements:

1. Bachelor's degree in statistics, mathematics, or in a related field from an accredited university or college. A bachelor's degree in some other discipline is also acceptable provided the applicant has a suitable mathematics background.

2. A 3.0 or higher (on a 4-point scale) GPA in mathematics and statistics courses.
3. Three letters of recommendation from persons familiar with the applicant's academic qualifications.
4. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.5 overall on the IELTS is required.
5. Approval of the departmental graduate committee.

Core Courses: (18)

STA 5206	Design of Experiments
STA 6244	Data Analysis I
STA 6246	Linear Models
STA 6247	Data Analysis II
STA 6326	Mathematical Statistics I
STA 6327	Mathematical Statistics II

Elective Courses: (12)

A student may select four courses from Lists A, B, and C or may opt for an area of concentration (see below).

Concentration Area: (12)

Students interested in a concentration in Biostatistics/ Environmetrics must select two courses from List A and two track-related electives. At least one of these electives must be from outside the department.

Students interested in a concentration in Reliability Analysis/Quality Control must select two courses from List B and two track-related electives. At least one of these electives must be from outside the department.

All electives must be approved by the Graduate Program Director.

List A: Biostatistics/Environmetrics

STA 5826	Stochastic Processes
STA 6176	Biostatistics
STA 6678	Environmental Statistics

List B: Reliability Analysis/Quality Control

STA 5666	Advanced Quality Control
STA 5676	Reliability Engineering
STA 5826	Stochastic Processes

List C: Elective Statistics Courses

STA 5207	Topics in Design of Experiments
STA 5236	Regression Analysis
STA 5507	Nonparametric Methods
STA 5906	Independent Study
STA 6505	Analysis of Categorical Data
STA 6807	Queueing and Statistical Models
STA 6940	Supervised Statistical Consulting
STA 7707	Multivariate Methods I
STA 7708	Multivariate Methods II

Elective Courses from Outside of the Department

Elective courses from outside of the department must be approved by the Graduate Program Director.

Thesis Option: (6)

Students opting to write a thesis must enroll in STA 6971, Thesis Research and STA 6972, Master's Thesis (6 credit-hours total).

Non-Thesis Option: (6)

Students who opt not to write a thesis must take two additional elective courses selected from List C or from outside of the department. These courses must be approved by the Graduate Program Director.

Graduation Requirements

1. Grade and GPA requirements: a) cumulative GPA of 3.0 or higher in all courses, b) an average grade of "B" or higher in all core courses, with a minimum grade of "C" or higher in each core course, and c) a grade of "C" or higher in each concentration or elective course.
2. A candidate who opts to write a thesis must successfully defend the thesis orally and have the written thesis approved by his/her thesis committee.
3. A candidate who chooses the non-thesis option must take and pass a comprehensive examination. Students must follow all regulations of the University Graduate School.

Course Descriptions

Definition of Prefixes

COT-Computing Theory; MAA-Mathematics: Analysis; MAD-Mathematics: Discrete; MAP-Mathematics: Applied; MAS-Mathematics: Algebraic Structures; MAT-Mathematics; MHF-Mathematics: History and Foundations; MTG-Mathematics: Topology and Geometry; STA-Statistics

F-Fall semester offering; S-Spring semester offering; SS-Summer semester offering

COT 5310 Theory of Computation I (3). Abstract models of computation; halting problem; decidability and undecidability; recursive function theory. Prerequisite: MAD 3512.

COT 6400 Analysis of Algorithms (3). Complexity behavior of algorithms is described for Set Manipulation, Graph Theory, and Matrix Manipulation problems, among others. P and NP classes of problems reveal an inherent difficulty in designing efficient algorithms. Prerequisite: COP 3530.

MAA 6616 Real Analysis (3). Function spaces, Lebesgue Measure and Integral with applications, properties of Lp spaces, differentiation, Radon-Nikodym theorem. Prerequisites: MAS 3105, MAA 4211, MAP 4401 or MAA 4212.

MAA 6506 Functional Analysis (3). Normed vector spaces, linear operators, Baire Category theorem, Banach fixed point theorem, Hahn-Banach theorem and applications, open mapping /closed graph theorem with applications, Hilbert spaces. Prerequisites: MAP 5406 AND MAA 6616.

MAD 5405 Numerical Methods (3). Advanced ideas and techniques of numerical analysis for digital computation. Topics include: linear and non-linear systems, ordinary differential equations, continuous system modeling techniques, and languages. Prerequisites: MAS 3105 and MAP 2302.

MAD 6409 Numerical Methods II (3). This course provides an exposure to numerical techniques used in solving partial differential equations of mathematical physics and engineering. Prerequisite: MAD 5405.

MAA 6406 Complex Analysis (3). Harmonic functions, normal families, Riemann mapping theorem, univalent functions, infinite products and entire functions, elliptic functions, analytic continuation. Prerequisites: MAA 4211 and MAA 4402.

MAA 6525 Advanced Topics in Functional Analysis (3). Continuation of MAA 6506. Topics may include distributional theory, monotone operators, variational methods, critical theory and direct application of these techniques. Prerequisite: MAA 6506 (or consent of the instructor)

MAD 6406 Numerical Linear Algebra (3). Topics from numerical linear algebra including solving systems of equations, direct and iterative methods and application, computing eigenvalues and eigenvectors. Prerequisite: MAS 3105 (or consent of the instructor)

MAD 7408 Topics in Numerical Analysis (3). Topics include numerical linear algebra, special methods, finite element methods, computational fluid dynamics, signal and image processing. Prerequisite: MAD 6409 Numerical Methods II.

MAP 5114 Basic Math for Machine Learning (3). A comprehensive and self-contained source of fundamental math tools (from Linear Algebra, Math Analysis, Optimization and Statistics) needed to successfully study and do Machine Learning. Prerequisites: MAS 3105 (Linear Algebra), MAC 2313 (Calculus 3), MAA 4211 (Advanced Calculus).

MAP 5117 Mathematical and Statistical Modeling (3). Study of ecological, probabilistic, and various statistical models. Prerequisites: MAC 2313, COP 2210, MAS 3105; and STA 3033 or STA 3164 or STA 4322.

MAP 5204 Optimization and Linear Algebra (3). Vectors, Euclidean spaces, operations on matrices, rank, determinants, linear and quadratic programming, Kuhn, Tucker techniques for constrained optimization. Prerequisite: MAC 2313.

MAP 5208 Numerical Optimization (3). The generalization of optimization theory and techniques to other formulations comprise a large area of applied mathematics. This course is mainly about convex optimizations. Prerequisites: MAP 2302, MAC 2313, MAS 3105.

MAP 5236 Mathematical Techniques of Operations Research (3). This course surveys the mathematical methods used in operations research. Topics will be chosen from linear programming, dynamic programming, integer programming, network analysis, classical optimization techniques, and applications such as inventory theory. Prerequisites: MAP 5117 and MAS 3105 and either CGS 3420 or COP 2210.

MAP 5255 Mathematical Scientific Computation (3). Programming in Matlab, Graphics in Matlab, Creating GUIs in Matlab, Simulink. Prerequisites: MAC 2313, MAP 2302, MAS 3105.

MAP 5316 Ordinary Differential Equations (3). Existence and uniqueness theorem, matrix formulation, physical applications, regular singular points, autonomous systems, Laplace transform, special topics. Prerequisites: MAA 3200, MAA 4402 and MAS 3105.

MAP 5317 Advanced Differential Equations for Engineers (3). Topics may include Bessel Functions and other special functions arising from classical differential equations, Sturm-Liouville problems, partial differential equations, transform techniques. Credit may not be counted for both MAP 4401 and MAP 5317. Credit for MAP 5317 may not be applied toward the Master's degree in Mathematical Sciences. Prerequisites: MAC 2313 and MAP 2302.

MAP 5318 Dynamical Systems and Introduction to Chaos Theory (3). Important techniques for linear systems of differential equations and nonlinear systems, as well as applications of these systems in a wide variety of fields. Prerequisites: MAS 3105, or equivalent, or permission of the instructor.

MAP 5406 Introduction to Functional and Applied Analysis (3). Metric and normed spaces, Hilbert spaces, fixed point theorems, linear operators, notions of convergence, applications to numerical integration, differential and integral equations. Prerequisites: MAA 4211, MAP 2302, and MAS 3105.

MAP 5414 Fourier Analysis and Wavelets (3). Introduction to Wavelets from Linear Algebra point of view, discrete and fast Fourier transform, data processing, compression of data, other applications to signal and image processing. Prerequisite: MAS 3105, MAA 4211, MAP 2302, MAP 3253 (or consent of the instructor)

MAP 5415 Introduction to Fourier Analysis (3). Basic real analysis, and measure theory, LP spaces and convolution, the Fourier transform in L^2, Plancherel theorem, application to differential equations and wavelets. Prerequisites: Advanced Calculus, Linear Algebra.

MAP 5467 Stochastic Differential Equations and Applications (3). Review of measure theory, stochastic processes, Ito Integral and its properties, martingales and their generalizations, stochastic differential equations, diffusions. Applications to boundary value problems and finance. Prerequisites: MAS 3105, MAP 4401, MAA 4211, MAA 6616 or permission of instructor.

MAP 5620 A Primer on the Mathematics of Environmental Financial Engineering (3). This course is an introductory course that presents the mathematical tools necessary for financial instrument, pricing and hedging design. Prerequisite: Working knowledge of Calculus and Basic Statistics and Probability.

MAP 5629 Quantitative Capstone in Environmental Finance (3). Analyze environmental/social/economic/ financial data to model and implement the structuring, pricing and hedging of creative financial instruments. Prerequisites: MAP 6622 and EVR 5086

MAP 6217 Calculus of Variations (3). Fundamental problems, weak and strong extrema, necessary and sufficient conditions, direct methods, optimal control problems, Pontryagin Maximum principle. Prerequisites: MAP 4401 and MAA 6616.

MAP 6218 Stochastic Calculus (3). Discrete time models, Brownian motion, stochastic integration, ITO's integral, Ornstein-Uhlenbeck processes, Girsanov theorem, Black-Sholes model. Prerequisites: STA 4321 or equivalent.

MAP 6326 Partial Differential Equations (3). Basic concepts of first and second order PDE's applications to optics and wave fronts, Cauchy problem, Laplace equation, Green's function, Dirichlet problem, heat equation. Prerequisite: MAA 4211.

MAP 6357 Partial Differential Equations II (3). Modern aspects of PDEs. Topics include distribution theory, fundamental solutions, maximum principles, Sobolev spaces, initial and boundary value problems. Prerequisites: MAA 6616 and MAP 6326.

MAP 6358 Partial Differential Equations in Fluid Mechanics (3). The mathematical theory for the partial differential equations modeling the inviscid and viscous incompressible fluids, namely, the Euler equations and the Navier-Stokes equations. Prerequisite: MAA 6616 and MAP 6326 (or consent of the instructor)

MAP 6416 Fourier Analysis (3). Continuation of "Introduction of Fourier Analysis" (MAP 5415). Topics may include interpolation, Sobolev spaces, oscillatory integrals, Hilbert transform, singular integrals, Littlewood-Paley theory. Prerequisite: MAP 5415, MAA 6616 (or consent of the instructor). Corequisite: preferred but not required: MAA 6406, MAA 6506.

MAP 6472 Probability and Stochastic Processes (3). This is an introductory course to diffusion processes. The topics include a detailed description of the Brownian motion with a wide range of properties as an example of a Markov process. Knowledge of PDE such as MAP 6326 is preferred but not required. Prerequisite: Consent of the instructor

MAP 6506 Advanced Methods of Mathematical Physics (3). Continuation of Functional Analysis (MAA 6506). Topics include compact and trace class operators, spectral theory, perturbation theory. Previous exposure to MAP 5415 is preferred but not required. Prerequisite: MAA 6406, MAA 6506 or consent of the instructor

MAP 6622 Quantitative Environmental Finance (3). This course presents an introduction to the history, use, design, market venues, pricing and performance of different types of weather derivatives, ESG portfolios, green bonds, real options analysis. Prerequisite: MAP 5620 or MAC 2312 and MAP 2302

MAP 6630 Numerical Methods in Risk Analysis and Management (3). Quadrature methods, numerical solutions to ODEs and PDEs, Monte Carlo method, applications to asset pricing. Prerequisites: Calculus 3, Matrix Algebra, Diff. Equations.

MAP 6631 Intro to Quantitative Risk Analysis and Management (3). A mathematical introduction to arbitrage-based pricing of derivative securities. Prerequisites: MAC 2313, MAS 3105.

MAP 6632 PDE in Risk Analysis and Management (3). Deterministic and stochastic optimization, dynamic programming, Hamilton-Jacob, equation, forward and backward Kolmogorov equation, Feynman-Kac formula. Prerequisites: Stochastic Calculus, Differential Equations, Calculus 3, Matrix Algebra.

MAP 6635 Risk Analysis and Management I (3). Basic probability, Martingales, Black-Sholes models, Black-Sholes formula, American options. Prerequisites: MAC 2313, MAS 3105, STA 4321. Corequisites: STA 4321 or equivalent.

MAP 6636 Risk Analysis and Management II (3). Discrete and continuous time models, application of stochastic integrals and ITO's Lemma to Finance, Risk of Neutral Valuation. Prerequisite: MAP 6635.

MAP 6637 Risk Analysis and Management III (3). Continuous time Risk Management. Arbitrage pricing theory. Exotix options. Interest rate models. Yield curves and pricing of interest rate derivative. Prerequisite: MAP 6636.

MAP 7359 Topics in Partial Differential Equations (0-9). Advanced topics in partial differential equations. Topics may include: fluid mechanics; inverse problems; microlocal and spectral analysis; scattering theory. Can be repeated. Prerequisite: MAP 6357.

MAP 7934 Seminar in Applied Mathematics (0-9). Various topics in applications of mathematics both classical and in areas of current research. Can be repeated for credit. Consent of instructor.

MAS 5145 Applied Linear Algebra (3). Vector spaces and linear maps, solutions of linear systems, orthogonal projection and QR factorization, determinant and eigenvalues of a matrix. Prerequisites: MAS 3105 and MAA 3200.

MAS 5311 Graduate Algebra (3). A study of the basic material on groups, rings and vector spaces. Topics include the Jordan-Holder theorem, structure of modules over Euclidean domains and canonical forms of matrices. Prerequisites: MAS 4301 or equivalent.

MAS 5312 Galois Theory (3). Extension fields, ruler and compass constructions, fundamental theorem of Galois Theory, cyclotomic and cyclic extensions, solutions of equations by radicals, selected topics. Prerequisites: MAS 5311 or permission of the instructor.

MAS 5315 Algebraic Geometry (3). Introduction to the theory of affine and projective schemes, coherent sheaves and sheaf cohomology. Application to studying algebraic varieties. Prerequisites: MAS 4301, MAA 4402.

MAS 5333 Commutative Algebra I (3). Study of regular, Cohen-Macaulay, and Gorenstein rings. Done using "local" and homological methods. Module of Kahler Differentials; integral closure of ideals; Intersection and applications. Prerequisite: MAS 4302.

MAT 5907 Independent Study (VAR). Individual conferences, assigned reading, and reports on independent investigations.

MAT 5921 Training in Mathematical Exposition (0). Students prepare and present supervised lectures on undergraduate mathematical topics to fellow students.

MAT 5970 Master's Research (1-6). Research toward preparation of master's project. Prerequisite: Permission of graduate committee.

MAT 6946 Applied Experience Component (1-3). Consists of a one semester (usually summer) internship at private corporation or government agency. Has three parts: i) weekly colloquia in math-science; ii) internship; iii) presentation after internship. Prerequisite: Permission of the department.

MAT 7908 Independent Study (1-3). For senior Ph.D. students to work on topics where standard courses cannot be opened. Could consist of individual conferences, assigned reading, or independent investigations. Prerequisite: Permission of the Math-Stats department.

MAT 7917 Graduate Research Seminar in Mathematics (3). Under supervision of faculty, students will read and present seminal papers in a field of mathematics. Course will train students reading and comprehension of research articles, and in preparing talks. Prerequisite: Permission of the department.

MAT 7980 Dissertation Research (1-9). Students conduct dissertation research at the doctoral level in mathematics under faculty supervision. Prerequisite: Permission of Instructor (F,S)

MAT 7981 PhD Dissertation (1-12). Original research work toward completion, presentation and defense of a dissertation. Prerequisite: Permission of Major Professor and Doctoral Candidacy (F,S,SS)

MHF 5107 Graduate Set Theory (3). Zermelo-Frankel axioms, ordinals and cardinals, Godel's constructible universe, large cardinals, forcing and the independence of the Continuum Hypothesis and the Axiom of Choice. Prerequisites: MHF 4102 or MAA 4211 or permission of the instructor.

MHF 5306 Graduate Mathematical Logic (3). First order languages, construction of models from constants, advanced construction of models, non-standard models, recursion theory, RE sets, Turing degrees, oracle construction. Prerequisites: MHF 4302 or permission of the instructor.

MHF 5325 Theory of Recursive Functions (3). Turing machines, decision problems, coding, s-m-n theorem, Rice's and Myhill's theorems, oracles, degrees, finite and infinite injury constructions. Prerequisite: MHF 4302 or COT 5310.

MHF 5345 Mathematical Logic for Linguistics (3). Formal logical systems and applications. Propositional and predicate calculus, proof systems, completeness and incompleteness theorems, recursion. Chomsky hierarchy, formal grammars. Does not fulfill requirements for Mathematics Degree. Prerequisites: MAD 3512 or permission of the instructor.

MHF 5930 Topics in Modern Mathematics (3). Designed to provide student with the opportunity to pursue topics not otherwise covered in other courses. Prerequisites: MAC 2313, MAS 3105.

MTG 5256 Differential Geometry (3). Curves and surfaces in 3-dimensional Euclidean space, Gauss-Bonnet Theorem, Smooth manifolds. Tensors on manifolds, Connections and curvature, Riemannian metrics. Prerequisite: MAC 2313, MAP 2302, MAS 3105 or equivalent

MTG 5257 Differential Geometry II (3). Continuation of "Differential Geometry". Topics include connections and curvature of fiber bundles, Lie groups. Additional topics chosen by the instructor. Prerequisite: MTG 4254 or MTG 5256 (or consent of the instructor)

MTG 5326 Introduction to Algebraic Topology (3). Classification of surfaces, fundamental group, homotopy type, Van Kampen theorem, simplicial complexes, introduction to homology theory. Prerequisites: MAS 4301 and MTG 4302.

MTG 5328 Introduction to Applied Topology (3). Persistence homology and diagrams of families of topological spaces; Stability Theorem; Probability and Statistics on the space of persistence diagrams; Applications to analyzing data. Prerequisite: MAS 3105, MAS 4302, MTG 4302, or equivalent.

MTG 5347 Algebraic Topology II (3). Continuation of "Introduction to Algebraic Topology" (MTG 5256). Topics include singular cohomology, Kunneth, universal coefficient, and duality theorems. Additional topics chosen by the instructor. Prerequisite: MTG 5256 (or consent of the instructor)

MTG 6255 Introduction to Riemannian and Symplectic Geometry (3). Tensors and forms on Smooth manifolds, Curves and surfaces, Riemannian metrics, Connections and curvature of manifolds, Symplectic manifolds, canonical coordinates, Lagrangian submanifolds. Prerequisite: MAS 3105, MAP 2303 and MAA 4211

STA 5065L SAS Data Analysis Lab (1). Entering data, descriptive statistics, graphing data, crosstabulations, t-tests, correlation and regression, and analysis of variance. Prerequisites: A statistics course and graduate standing or permission of the instructor.

STA 5105L SPSS Data Analysis Lab (1). Topics include: Entering data from various sources, data checking, descriptive statistics, graphing data, crosstabulations, t-tests, correlation and regression, ANOVA, and reliability. Prerequisites: A statistics course or concurrent enrollment in a statistics course, and graduate standing or permission of the instructor.

STA 5106 Intermediate Statistics I (3). Power, measures of assoc., measurement, ANOVA: one-way and factorial, between and within subjects expected mean squares, planned comparisons, apriori contrasts, fixed, random, mixed models. This course may be of particular interest to behavioral sciences. Prerequisites: STA 3111 or STA 3123 or STA 3033; and graduate standing. (F)

STA 5107 Intermediate Statistics II (3). Correlation and regression both simple and multiple, general linear model, analysis of covariance, analysis of nominal data, analysis of categorical data. This course may be of particular interest to behavioral sciences. Prerequisite: Permission of the instructor. (S)

STA 5126/PSY 5206 Fundamentals of Design of Experiments (3). CRD and RCB designs. Latin square designs. Factorial, nested and nested-factorial experiments. Fixed, random and mixed models. Split-plot designs. Covariance analysis. Prerequisites: STA 3112 or STA 3123 or STA 3163 or STA 4322 or equivalent.

STA 5206 Design of Experiments I (3). Design and analysis of completely randomized block, Latin square factorial, nested experiments. Multiple comparisons. Credit for only one of three STA 4202, STA 5126, and STA 5206 courses will be granted. Prerequisites: STA 3033 or STA 3164 or STA 4322 or (STA 3163 and STA 4321).

STA 5207 Topics in Design of Experiments (3). This applied course in design of experiments covers topics such as split-plot design, confounding, fractional replication, incomplete block designs, and response surface designs. Prerequisite: STA 5206.

STA 5236 Regression Analysis (3). Simple, multiple and polynomial regression, analysis of residuals, model building and other related topics. Credit for both STA 4234 and STA 5236 will not be granted. Prerequisites: STA 3112 or STA 3123 or STA 3164, or STA 6167.

STA 5446-STA 5447 Probability Theory I and II (3-3). This course is designed to acquaint the student with the basic fundamentals of probability theory. It reviews the basic foundations of probability theory, covering such topics as discrete probability spaces, random walk, Markov Chains (transition matrix and ergodic properties), strong laws of probability, convergence theorems, and law of iterated logarithm. Prerequisite: MAC 2313.

STA 5507 Nonparametric Methods (3). Distribution-free tests: sign, Mann-Whitney U, Wilcoxon signed rank, Kruskal-Wallis, Friedman, etc. Rank correlation, contingency tables and other related topics. Credit for both STA 4502 and STA 5507 will not be granted. Prerequisite: A course in statistics.

STA 5666 Advanced Statistical Quality Control (3). Review of statistical methods useful in quality improvement. Statistical process control. Taguchi’s and Deming’s philosophies. Control charts. Process capability analysis. Acceptance sampling plans. Prerequisites: STA 3033 or STA 3163 or STA 4321 or equivalent.

STA 5676 Reliability Engineering (3). The course material is designed to give the student a basic understanding of the statistical and mathematical techniques which are used in engineering reliability analysis. A review will be made of the basic fundamental statistical techniques required. Subjects covered include: distributions used in reliability (exponential, binomial, extreme value, etc.); tests of hypotheses of failure rates; prediction of component reliability; system reliability prediction; and reliability apportionment. Prerequisite: STA 4322.

STA 5800 Stochastic Processes for Engineers (3). Probability and conditional probability distributions of a random variable, bivariate probability distributions, multiple random variables, stationary processes, Poisson and normal processes. Prerequisites: MAC 2313, MAP 2302, STA 3033.

STA 5826 Stochastic Processes (3). This course is intended to provide the student with the basic concepts of stochastic processes, and the use of such techniques in the analysis of systems. Subjects include: Markov Processes, queueing theory, renewal processes, birth and death processes, Poisson and Normal processes. Applications to system reliability analysis, behavioral science, and natural sciences will be stressed. Prerequisite: STA 5447.

STA 5906 Independent Study (1-6). Individual conferences, assigned reading, and reports on independent investigation.

STA 6166 - STA 6167 Statistical Methods in Research I and II (3-3). For non-mathematical sciences graduate students. A non-calculus exposition of methods and applications of statistical techniques for the analysis of data. Statistical packages will be used. Prerequisite: Graduate standing. (F,S)

STA 6176 Biostatistics (3). Statistical analysis of data encountered in medical sciences. Analysis of count data, Kaplan-Meier survival analysis, Cox proportional hazards model, analysis of covariance, logistic regression, etc. Prerequisites: STA 3163 or equivalent.

STA 6196 Statistics for Environmental Sciences (3). Environmental Quality Data, Binomial, Poisson, Normal, Lognormal, and Extreme value distributions. Prediction and Tolerance Intervals, Hypothesis Testing of Environmental Quality Data, Risk Assessment, Regression, Spatial Statistics. Prerequisites: STA 2122, STA 3145, STA 6166 or the equivalent.

STA 6244 Data Analysis I (3). Exploratory data analysis; testing of distributional assumptions; Chi-square tests, tests for means, variances, and proportions. Prerequisites: STA 3033, STA 4322, or STA 6327.

STA 6246 Linear Models (3). Introduction to the theory of linear models. Distribution of linear and quadratic functions of normal vectors. Development of inferential procedures for simple and other more complex linear models Prerequisites: MAS 3105, STA 6247, and STA 6327.

STA 6247 Data Analysis II (3). Analysis of variance, regression analysis. Analysis of covariance, quality control, correlation, empirical distributions. Prerequisites: MAS 3105 and STA 6244.

STA 6326 Mathematical Statistics I (3). An introduction to the theories underlying statistical analysis. Basic concepts of probability theory, combinatorial analysis, random variables, and expectation. Prerequisite: MAC 2313.

STA 6327 Mathematical Statistics II (3). Estimation of parameters, tests of hypotheses, regression, non-parametric methods, analysis of variance, and multivariate concepts. Prerequisite: STA 6326.

STA 6505 Analysis of Categorical Data (3). Analysis of contingency tables, measures of association, logit and loglinear models. Prerequisites: STA 5107 or STA 5236 or STA 6167.

STA 6636 High Dimension Data Analysis (3). Statistical techniques used to analyze high dimensional data sets. Topics include machine learning, high dimensional data, discriminant analysis and clustering. Prerequisites: STA 6246 and STA 5236 or equivalent.

STA 6678 Environmental Statistics (3). Review of probability theory and probability processes. Bernoulli, Poisson, and normal processes. Dilution of pollutants. Lognormal processes. Prerequisites: MAC 2312 and STA 3164.

STA 6746 Multivariate Statistical Analysis (3). Multivariate normal, Wishart and Hotelling's distributions. Statistical inferences based on one or two samples. MANOVA. Principal component analysis, factor analysis, and cluster analysis. Prerequisites: STA 3112 or STA 3123 or STA 6167.

STA 6807 Queueing and Statistical Models (3). Review of probability concepts, basic probability distributions, Poisson process, queuing models, statistical models.

Prerequisites: Permission of the instructor, MAC 2312 and either STA 3033 or STA 4321.

STA 6930 Special Topics (3). A course designed to give students an opportunity to pursue special studies not otherwise offered in the curriculum. May be repeated. Prerequisite: Permission of the instructor.

STA 6940 Supervised Statistical Consulting (3). Formulation of statistical problems from client information, consulting session management, interpersonal aspects of consulting, problem solving techniques. Prerequisites: Permission of the instructor, STA 4102, STA 6247, and STA 6327.

STA 6870 Time Series Analysis (3). Stationarity, autocorrelation, autoregressive moving average (ARIMA) models; partial autocorrelation; statistical inference and R; non-stationarity; seasonality; forecasting; spectral methods. Prerequisite: STA 4322 or equivalent

STA 6971 Thesis Research (1-6). Supervised research on theoretical or applied statistics leading to a thesis. Repeatable. Prerequisite: Permission of student's program committee.

STA 6972 Master's Thesis (1-6). Thesis completion and submission in partial fulfillment of Master's degree requirements. Prerequisite: Permission of student's program committee.

STA 7707 Multivariate Methods I (3). Multivariate normal, Wishart and Hotelling's distributions. Inferences for one and two mean vectors. Profile analysis. One- and two-way MANOVA. Multivariate multiple regression. Prerequisites: STA 3112 or STA 3123. (F)

STA 7708 Multivariate Methods II (3). Principal components analysis. Factor analysis. Canonical correlation analysis. Discriminant analysis. Cluster analysis. Multidimensional scaling. Prerequisite: STA 7707. (S)

STA 7980 PhD Dissertation (0-15). Original research work toward completion, presentation, and defense of a dissertation. Prerequisite: Doctoral Candidacy and Permission of Major Professor (F, S. SS)