**Department of Mathematics**
**Master of Science in Applied Mathematics**
**Program Code: AMTH**
**Effective Date: 2019-2020 Academic Year**

# Curriculum Guides

A student seeking the Master of Science in Applied Mathematics must complete the following:

- 30 credit hours of graduate course work.
- Three core courses (9 credit hours): MATH 603, 651, and 690.
- A thesis or a project.
- Master's Comprehensive Examination (MATH 788: 0 credit hour)

Thesis option:

- Take 9 credit hours of 700 level MATH **or STAT** courses with approval of advisor
- Take 6 credit hours of additional graduate courses with approval of advisor
- Master's Thesis (MATH 797: 6 credit hours)
- Pass Master's Thesis defense

Project Option:

- Take 12 credit hours of 700 level MATH **or STAT** courses with approval of advisor
- Take 6 credit hours of additional graduate courses with approval of advisor
- Graduate Design Project (MATH 796: 3 credit hours)
- Pass Graduate Design Project oral examination

## List of Graduate Mathematics Courses

**MATH 603.** Introduction to Real Analysis. Credit 3(3-0)

The following topics will be covered in this course: elementary set theory, functions, axiomatic development of the real numbers, metric spaces, convergent sequences, completeness, compactness, connectedness, continuity, limits, sequences of functions, differentiation, the mean value theorem, Taylor's theorem, Riemann integration, infinite series, the fixed point theorem, partial differentiation, and the implicit function theorem. Prerequisite: MATH 211 or consent of the instructor. (DEMAND)

**MATH 607.** Theory of Numbers. Credit 3(3-0)

Divisibility properties of the integers, the Euclidean algorithm, congruences, diophantine equations, number-theoretic functions and continued fractions will be studied. Prerequisite: Twenty hours of college mathematics. (DEMAND)

**MATH 610.** Complex Variables. Credit 3(3-0)

The following topics will be covered in this course: complex number systems, limits of complex sequences, complex functions, continuity, limits of functions, derivatives, elementary functions, Cauchy-Riemann equations, Prerequisite: Math 332 or consent of instructor. (DEMAND)

**MATH 620.** Elements of Set Theory and Topology. Credit 3(3-0)

Operations on sets, indexed families of sets, products of sets, relations, functions, metric spaces, general topological spaces, continuity, compactness and connectedness will be included. Prerequisites: MATH 231 and consent of the instructor. (DEMAND)

**MATH 623.** Probability Theory and Applications. Credit 3(3-0)

This course begins with an introduction to sample spaces and probability, including combinatorics. It covers continuous and discrete random variables, including multi-variate random variables and expectations; also marginal and conditional distributions are derived. The course introduces moment generating functions, and covers the central limit theorem and its applications. Prerequisite: MATH 231. (DEMAND)

**MATH 624.** Theory and Methods of Statistics. Credit 3(3-0)

This course introduces methods of statistical estimation and inference including the following topics: sufficient statistics, confidence sets, hypothesis tests, and maximum likelihood methods. The theory of uniformly most powerful tests and the Neyman-Pearson Lemma are covered. Other topics include least squares estimation, the linear model, and Bayesian methods. Prerequisite: MATH 623. (DEMAND)

**MATH 631.** Linear and Non-Linear Programming. Credit 3(3-0)

This course includes optimization subject to linear constraints; transportation problems, SIMPLEX algorithm; network flows; application of linear programming to industrial problems and economic theories; introduction to non-linear programming. Prerequisites: MATH 350 and a high level programming language. (DEMAND)

**MATH 632.** Games and Queue Theory. Credit 3(3-0)

This course is a general introduction to game theory; two-person-non-zerosum-non-cooperative games; two-person cooperative games; reasonable outcomes and values; the minimax theorem. Introduction to queuing theory; single server queuing processes; many serve queuing processes; applications to economics and business. Prerequisite: MATH 224, MATH 350, or consent of the instructor. (DEMAND)

**MATH 633.** Stochastic Processes. Credit 3(3-0)

This course begins with a review of Probability and Random Variables. Markov Processes, Poisson Processes, Waiting Times, Renewal Phenomena, Branching Processes, Queuing System, Service Times are covered. Prerequisite: MATH 623 or consent of the instructor. (DEMAND)

**MATH 650.** Ordinary Differential Equations. Credit 3(3-0)

This is an intermediate course in ordinary differential equations with emphasis on applications. Topics include linear systems and various phase plane techniques for non-linear ordinary differential equations. Prerequisite: MATH 332. (DEMAND)

**MATH 651.** Partial Differential Equations. Credit 3(3-0)

This course includes introduction to complex variables and residue calculus, transform calculus, higher order partial differential equations governing various physical phenomena, nonhomogeneous boundary value problems, orthogonal expressions, Green's functions and variational principles. Prerequisites: MATH 333 and 432. (DEMAND)

**MATH 652.** Methods of Applied Mathematics. Credit 3(3-0)

This course covers matrix theory, systems of linear equations, vector spaces, eigenvalue problem and its applications to systems of linear ODEs and mechanical vibrations, the simplest problems of calculus of variations, Euler equations, boundary conditions, extensions of Euler equations, Hamilton's Principles, constraints and Lagrange multipliers, introduction to integral equations, and solutions in iterative and other methods. Prerequisites: MATH 332 and 432. (DEMAND)

**MATH 665.** Principles of Optimization. Credit 3(3-0)

Algebra, linear inequalities, duality, graph, transport network; linear programming; special algorithms; selected applications. An upper level course. Prerequisites: MATH 231 or equivalent and MATH 240 and 350. (DEMAND)

**MATH 675.** Graph Theory. Credit 3(3-0)

Varieties of graphs, graph theory algorithms, and applications of graph theory to other disciplines will be studied. Prerequisite: MATH 350. (DEMAND)

**MATH 685.** Special Topics in Applied Mathematics. Credit 3(3-0) (Formerly **MATH 691**)

Topics are selected from differential equations, numerical methods, operations research, applied mechanics and from other fields of applied mathematics. Prerequisites: Senior or graduate standing and consent of the instructor. (DEMAND)

**MATH 690.** Scientific Programming for Mathematical Scientists. Credit 3(1-4)

This course covers the implementation of the computer in the Mathematical sciences. MATLAB will be used to apply algorithms and solve problems in areas such as differential equations and linear algebra. Probability and statistical problems will be studied through the R language. Prerequisites: Senior or graduate standing or consent of instructor.

**MATH 700.** Theory of Functions of One Real Variable I. Credit 3(3-0)

The focus of this course is a careful study of the fundamental theorems of Lebesgue theory, including Lebesgue measure, differentiation and integration on the real line. Topics from set theory and point set topology are also included in this course. Prerequiste: MATH 407 or equivalent.

**MATH 701.** Theory of Functions of One Real Variable II. Credit 3(3-0)

This course is a continuation of MATH-700. The following topics will be covered in this course: general measure and integration, measure and outer measure, and some basic topics from functional analysis. Prerequisite: MATH 700. (DEMAND)

**MATH 705.** Graduate Seminar. Credit 1(1-0)

The seminars will present current developments and ideas in applied mathematics and computational science. Topics explored may consist of material from various mathematics and computational science journals, including discussion of research by faculty and students. This course may be repeated for up to 3 credit hours. Prerequisite: Graduate Standing.

**MATH 706.** Categorical Data Analysis. Credit 3(3-0)

This course will include the following topics: Two-Way Contingency Table Inference for Two-Way Table, Models for Binary Response Variables, Log-linear Models, Testing in Loglinear Models, Multinomial Response Models and Estimation Theory for Parametric Models, and Computer Analysis of Categorical Data. Prerequisite: MATH 624. (DEMAND)

**MATH 708.** Nonparametric Statistics. Credit 3(3-0)

The following topics will be discussed in this course: Order Statistics, Run Test for Trend, Goodness of Fit Tests, Rank Tests for One and Two Populations, Linear Rank Statistics, One-Way and Two-Way Nonparametric Analysis of Variance, and applications to practical problems. Prerequisite: MATH 624. (DEMAND)

**MATH 709.** Discrete and Combinatorial Mathematics for Data Science. Credit 3(3-0)

This course introduces topics in discrete and combinatorial mathematics that underlie areas in data science and big data analytics. Topics covered include graphs and trees, graph coloring, matchings, the pigeonhole principle, induction and recursion, generating functions,

combinatorics, and combinatorial optimization. The course integrates learning mathematical theories with applications to concrete problems from data science using discrete modeling techniques. Prerequisite: STAT 707. (F;S;SS)

**MATH 710.** Theory of Functions of One Complex Variable. Credit 3(3-0)

This course includes basic theory of analytic functions, including Cauchy's theorem, conformal mappings, Taylor and Laurent series, and residue theory. Prerequisite: MATH 377 or equivalent. (DEMAND)

**MATH 712.** Numerical Linear Algebra. Credit 3(3-0)

Numerical analysis for solution of linear systems, approximation methods foreign values and eigenvectors, least squares solutions, ill-posed and ill-conditioned systems and error analysis are covered. Prerequisite: One programming language, MATH 351 or equivalent. (DEMAND)

**MATH 717.** Special Topics in Algebra. Credit 3(3-0)

This course covers selected topics in algebra. Topics covered will be determined by the instructor. Prerequisites: Consent of the instructor and graduate standing. (DEMAND)

**MATH 720.** Special Topics in Analysis. Credit 3(3-0)

This course covers selected topics in analysis. Topics covered will be determined by the instructor. Prerequisites: Consent of the instructor and graduate standing. (DEMAND)

**MATH 721.** Multivariate Statistical Analysis. Credit 3(3-0)

Multivariate normal distribution, inference about a mean vector, comparison of several multivariate means, analysis of Covariance Structure, Analysis of Dispersion, classification and Clustering Techniques and Some Applications of Multivariate Tests will be discussed in this course. Also, practical examples of industrial use will be addressed. Prerequisites: MATH 608 and MATH 624. (DEMAND)

**MATH 723.** Advanced Topics in Applied Mathematics. Credit 3(3-0)

This course is designed to cover important topics in applied mathematics that may be desired from time to time for specific students in the graduate program. It may also be used as a vehicle for development of new courses for graduate program students. Prerequisite: consent of the instructor. (DEMAND)

**MATH 731.** Advanced Numerical Methods. Credit 3(3-0)

This course covers numerical methods for solution of parabolic, elliptic and hyperbolic boundary value problems. Problems are selected from engineering applications. Both finite difference and finite element methods are studied. Prerequisite: MATH-460 or equivalent. (DEMAND)

**MATH 733.** Advanced Probability & Stochastic Process. Credit 3(3-0)

The following topics will be discussed in this course: introduction to Lebesque integration. probability theory and random variables, laws of large numbers, central limit theorems, random walks, martingales,

Markov processes and Markov chains, ergodic theorems and Brownian motion. Prerequisite: MATH 603 or permission of the instructor. (DEMAND)

**MATH 752.** Calculus Variations and Control Theory. Credit 3(3-0)

This course covers the following topics: functionals, Euler's equation, Lagrange multipliers. Kuhn-Tucker conditions, Pontryagin maximum principle, Weiserstrass- Edmann corner conditions. Euler-Legrange equations; first and second variational problems. Applications to engineering areas will also be included. Prerequisites: MATH 341 and MATH 432 or equivalent. (DEMAND)

**MATH 761.** Interdisciplinary Computational Science Project I. Credit 3(3-0) (Formerly **MATH 791**)

This course continues development of skills required for independent research or problem-solving in the realm of computational science. The course requires completion of an agreed upon computational project, based upon a sound literature review, under the guidance of the instructor. Prerequisite: MATH 380 or equivalent. (DEMAND)

**MATH 762.** Interdisciplinary Computational Science Project II. Credit 3(3-0) (Formerly **MATH 792**)

This course continues development of skills required for independent research or problem-solving in the realm of computational science. The course requires completion of an agreed upon computational project, based upon a sound literature review, under the guidance of the instructor. Prerequisite: MATH 761. (DEMAND)

**MATH 781.** Mathematical & Computational Modeling. Credit 3(3-0)

This course explores the steps required to model and simulate a system, including discussion of generic governing equations, grid generation, basic numerical schemes, simulation strategies, and data analysis. Both discrete and continuous methods used in scientific applications will be examined. Representative applications include weather prediction, molecular dynamics, scheduling problems, and engine combustion modeling. Prerequisite: MATH 380 or equivalent. (DEMAND)

**MATH 782.** Statistical Data Analytics and Visualization. Credit 3(3-0)

This course explores statistical methods and computational programming skills for data analytics and visualization. Topics covered include linear regression, generalized linear regression, classification, text analytics, clustering, and visualization. This course provides practical and prudent applications of data analytics methods to real world problems with contemporary programming tools. Prerequisite: MATH 608 or MATH 624 or MATH 721. (F;S;SS)

**MATH 788.** Master's Comprehensive Exam. Credit 0(0-0)

Examination. (DEMAND)

**MATH 796.** Graduate Design Project. Credit 3(3-0) (Formerly **MATH 725**)

This course requires independent project work on an advanced mathematical topic of interest to the student and a faculty member acting as the student's advisor. The topic must be approved by the advisor. Prerequisite: Consent of the instructor. (DEMAND)

**MATH 797.** Thesis Research in Mathematics. Credit 3(3-0) (Formerly **MATH 730**)

Students who select the thesis option must do advanced research in an area of interest. The research topic must be approved by the thesis advisor. (DEMAND)

**MATH 799**. Continuation of Thesis for Mathematics. Credit 1(1-0) (Formerly **MATH 799**)

**STAT 707.** Introduction to Data Science. Credit (3-0)

This course covers the data science concepts and skills needed to collect, manipulate, compute with, and interpret data. The students will learn to write R, SAS and/or Python programs that manipulate and visualize data, and they will learn statistical inference, predictive modeling and machine learning techniques essential to analyzing and presenting data. Prerequisite: Graduate Standing. (F;S;SS) Graduate standing and permission of instructor.

**STAT 708**. Linear Models for Data Science. Credit (3-0) (Formerly MATH 608)

The course introduces principles and methods of least squares regression and design of experiments that are used to solve data science problems. Least squares regression covers simple and multiple linear regression, including estimation, inference, model building and variable selection. Design of experiments introduces statistically designed experiments and related-analytical methods. The course utilizes statistical programming language such as R, SAS, and/or Python. Prerequisite: STAT 707 or permission of instructor (F;S;SS)

**STAT 710**. Statistical and Deep Learning. Credit (3-0)

This course covers advanced topics in statistical and deep learning. The course provides a statistical approach to neural network algorithms and artificial intelligence complex high-dimensional problems in business and the social, natural, and life sciences Prerequisite: STAT 707. (F;S;SS)

**STAT 711.** Statistical Computing and Algorithm Analysis. Credit (3-0)

This course covers both theoretical and practical issues of statistical computing and algorithms required in modern data science. Students will learn how to develop algorithms for statistical methods and apply them to-data science problems. Topics include resampling methods, EM algorithms, Markov chain Monte Carlo simulation, gradient-based optimization, and nonparametric curve fitting. Prerequisite: STAT 707. (F;S;SS)