Mathematics (MATH)

MATH _0110: Intermediate Algebra
MATH _0110 is a preparatory course for college algebra that carries no credit towards any baccalaureate degree. However, the grade received in MATH _0110 does count towards a student's overall GPA. The course covers operations with real numbers, graphs of functions, domain and range of functions, linear equations and inequalities, quadratic equations; operations with polynomials, rational expressions, exponents and radicals; equations of lines. Emphasis is also put on problem-solving.

Credit Hours: 3

MATH 1050: Quantitative Reasoning
Promotes mathematical literacy among students. This course will cover important mathematical ideas and problem solving skills in the context of science, technology, and/or society. Topics may include: logic and critical thinking, Venn Diagrams, problem solving, sets, units of measure, percentages and ratios, counting and probability, exponential growth and decay, linear and exponential models. Quantitative Reasoning is designed to stimulate interest in and appreciation of mathematics and quantitative reasoning as valuable tools for comprehending the world in which we live. This course does not satisfy the prerequisite of any other MATH course.

Credit Hours: 3
Prerequisites: C- or higher in MATH _0110 or a sufficient score on the myMath test
MATH 1050 - MOTR MATH 120: Mathematical Reasoning Modeling

MATH 1100: College Algebra
A review of exponents, order of operations, factoring, and simplifying polynomial, rational, and radical expressions. Topics include: linear, quadratic, polynomial, rational, inverse, exponential, and logarithmic functions and their applications. Students will solve equations involving these functions, and systems of linear equations in two variables, as well as inequalities. See the Math website for specific requirements. Students may receive credit for MATH 1100 or MATH 1160, but not both.

Credit Hours: 3
Prerequisites: C- or higher in MATH _0110 or MyMathTest Intermediate Algebra score of 70% or higher
MATH 1100 - MOTR MATH 130: Pre-Calculus Algebra

MATH 1140: Trigonometry
Students may receive credit for MATH 1140 or MATH 1160, but not both.

Credit Hours: 2
Prerequisites: C- or higher in MATH 1100 or MyMathTest College Algebra score of 70% or higher

---

MATH 1160: Precalculus Mathematics
Review of elementary algebra. Background material for MATH 1500, including algebraic, trigonometric, logarithmic, exponential functions. Students may receive credit for MATH 1100 or MATH 1160, but not both. Students may receive credit for MATH 1140 or MATH 1160, but not both.

Credit Hours: 5
Prerequisites: B+ or higher in MATH _0110 (at MU), or C- or higher in MATH 1100, or MyMathTest College Algebra score of 60% or higher
MATH 1160 - MOTR MATH 150: Pre-Calculus

MATH 1300: Finite Mathematics
A selections of topics in finite mathematics such as: basic financial mathematics, counting methods and basic probability and statistics, systems of linear equations and matrices.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1100 OR MATH 1160; or both a College Algebra exemption AND a MyMathTest College Algebra score of 70% or higher

---

MATH 1300H: Finite Mathematics - Honors
A selections of topics in finite mathematics such as: basic financial mathematics, counting methods and basic probability and statistics, systems of linear equations and matrices.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1100 OR MATH 1160; or both a College Algebra exemption AND a MyMathTest College Algebra score of 70% or higher. Honors eligibility required

---

MATH 1360: Geometric Concepts
This course is primarily for education majors. This course covers topics of Euclidean geometry such as the study of points, lines, angles, polygons, circles, congruence, similarity, transformations, symmetry, area, surface area, arc length, and volume. Polyhedra, spheres, cones, and other solids are discussed. The course includes constructions and proofs, and uses inductive and deductive reasoning throughout. Math Reasoning Proficiency Course.

Credit Hours: 3
Prerequisites: C- or higher in MATH 1100 or sufficient ALEKS exam score or MATH 1160 or equivalent

---

MATH 1400: Calculus for Social and Life Sciences I
The real number system, functions, analytic geometry, derivatives, integrals, maximum-minimum problems. No credit for students who have completed a calculus course. Students may receive credit for MATH 1400 or MATH 1500.

Credit Hours: 3
Prerequisites: grade of C- or higher in MATH 1100, or MATH 1160, or Math Placement Test College Algebra score of 70%

MATH 1500: Analytic Geometry and Calculus I
Elementary analytic geometry, functions, limits, continuity, derivatives, antiderivatives, definite integrals. Students may receive credit for MATH 1400 or MATH 1500, but not both.

Credit Hours: 5
Prerequisites: grade of C- or higher in MATH 1160 or C - or higher in both MATH 1100 and MATH 1140 or Math Placement Test PreCalculus score of 70% or higher

---

MATH 1500H: Analytic Geometry and Calculus I - Honors
Elementary analytic geometry, functions, limits, continuity, derivatives, antiderivatives, definite integrals. A student may receive at most 5 units of credit among MATH 1320 or MATH 1400 and MATH 1500.

Credit Hours: 5
Prerequisites: C- or higher in MATH 1160 or C- in both MATH 1100 and MATH 1140 and sufficient ALEKS score. Honors Eligibility required

---

MATH 1601: Selected Topics in Mathematics-General
The special topics covered may vary from term to term. This course may be repeated.

Credit Hour: 1-3
Prerequisites: instructor's consent

MATH 1602: Selected Topics in Mathematics-Biological/Physical/ Math
The special topics covered may vary from term to term. This course may be repeated.

Credit Hour: 1-3
Prerequisites: instructor's consent

MATH 1700: Calculus II
Definite integrals, applications and techniques of integration, elementary transcendental functions, infinite series. Math Proficiency Reasoning course.

Credit Hours: 5
Prerequisites: a grade of C- or better in MATH 1500

MATH 1700H: Calculus II - Honors
Definite integrals, applications and techniques of integration, elementary transcendental functions, infinite series.

Credit Hours: 5
Prerequisites: a grade of C- or better in MATH 1500. Honors eligibility required

---

MATH 2100: Calculus for Social and Life Sciences II
Riemann integral, transcendental functions, techniques of integration, improper integrals, functions of several variables and ordinary differential equations. No credit for students who have completed two calculus courses. Math Reasoning Proficiency course.

Credit Hours: 3
Prerequisites: C- or higher in MATH 1320 or MATH 1400 or MATH 1500

MATH 2300: Calculus III
Vectors, solid analytic geometry, calculus of several variables.

Credit Hours: 3
Prerequisites: grade of C- or better in MATH 1700

MATH 2300H: Calculus III - Honors
Vectors, solid analytic geometry, calculus of several variables. .

Credit Hours: 3
Prerequisites: grade of C or better in MATH 1700. Honors eligibility required

---

MATH 2320: Discrete Mathematical Structures
Sets, functions, logic, relations, induction, recursion, counting techniques, graphs, trees, algorithms. Math Reasoning Proficiency course.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1400 or Grade of C- or higher in MATH 1500

MATH 3000: Introduction to Advanced Mathematics
Gateway to theoretical math courses. Focus on reading and writing math proofs/rigorously developing background needed in Adv Calc/Abstract Alg. Topics include logic, set theory, properties of functions and integers, the real number system, completeness of the real numbers, sequences of real numbers.

Credit Hours: 3
Prerequisites: Consent of Department required
Recommended: MATH 1700

MATH 3000W: Introduction to Advanced Mathematics - Writing Intensive
Gateway to theoretical math courses. Focus on reading and writing math proofs/rigorously developing background needed in Adv Calc/Abstract Alg. Topics include logic, set theory, properties of functions and integers, the real number system, completeness of the real numbers, sequences of real numbers.

Credit Hours: 3
Prerequisites: Consent of Department required
Recommended: MATH 1700

MATH 4001: Topics in Mathematics-General
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

Credit Hour: 1-99
Prerequisites: Grade of C- of higher in MATH 2300

MATH 4002: Topics in Mathematics-Biological Sciences
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

Credit Hour: 1-6
Prerequisites: MATH 2300 and instructor's consent

MATH 4006: Topics in Mathematics-Mathematical Sciences
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

Credit Hour: 1-6
Prerequisites: MATH 2300 and instructor's consent

MATH 4007: Topics in Mathematics-Physical Sciences
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

Credit Hour: 1-6
Prerequisites: MATH 2300 and instructor's consent

MATH 4060: Connecting Geometry to Middle and Secondary Schools
(cross-leveled with MATH 7060). Euclidean foundations, logic, Euler Characteristic, congruence, area, Pick's Theorem, volume, Cavalieri's Principle, surface area, similarity, symmetry, transformations, matrices, and an introduction to spherical geometry.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1360 or MATH 1500. Enrollment is restricted to students in the College of Education

---

MATH 4070: Connecting Algebra to Middle and Secondary Schools
(cross-leveled with MATH 7070). A detailed study of integer and rational arithmetic and algebra. Topics include the Binomial Theorem, mathematical induction, division algorithm, Euclid's Algorithm, Fundamental Theorem of Arithmetic, Pythagorean triples, modular arithmetic and generalizations to polynomials, matrices and other axiomatic structures.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1400 or MATH 1500. Enrollment is restricted to students in the College of Education

---

MATH 4080: Calculus Connections
Course topics include: sequences, series, functions, limits, continuity, differentiation, optimization, curve sketching, antidifferentiation, areas of plane regions, lengths of plane curves, areas of surfaces of revolution, and volumes of solids.

Credit Hours: 3
Prerequisites: MATH 1160, enrollment is restricted to Math Education majors

---

MATH 4100: Differential Equations
(cross-leveled with MATH 7100). Traditional introductory course in ordinary differential equations. Includes 1st and 2nd order linear differential equations with numerous applications; Laplace transforms; power series solutions; numerical methods, linear systems.

Credit Hours: 3
Prerequisites: Grade of C- or above in MATH 2300

MATH 4100H: Differential Equations - Honors
(cross-leveled with MATH 7100). Traditional introductory course in ordinary differential equations. Includes 1st and 2nd order linear differential equations with numerous applications; Laplace transforms; power series solutions; numerical methods, linear systems.

Credit Hours: 3
Prerequisites: Grade of C- or above in MATH 2300; Honors eligibility required

---

MATH 4120: Graph Theory and Combinatorics
(cross-leveled with MATH 7120). This course provides an introduction to graph theory and related topics in combinatorics. Topics include counting spanning trees, colorings of graphs and chromatic polynomials, matchings, network flows, and planar graphs.

Credit Hours: 3
Prerequisites: MATH 2320 or MATH 3000 or instructor's consent

---

MATH 4140: Matrix Theory
(cross-leveled with MATH 7140). Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 or MATH 2320. Writing intensive sections require ENGLSH 1000

MATH 4140W: Matrix Theory - Writing Intensive
Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 or MATH 2320. Writing intensive sections require ENGLSH 1000

MATH 4150: History of Mathematics
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored.

Credit Hours: 3
Prerequisites or Corequisites: MATH 2300 or MATH 2340. Writing intensive sections require ENGLSH 1000

MATH 4150W: History of Mathematics - Writing Intensive
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored.

Credit Hours: 3
Prerequisites or Corequisites: MATH 2300 or MATH 2340. Writing intensive sections require ENGLSH 1000

MATH 4300: Numerical Analysis
(cross-leveled with MATH 7300). Machine arithmetic, approximation and interpolation, numerical differentiation and integration, nonlinear equations, linear systems, differential equations, error analysis. Selected algorithms will be programmed for solution on computers so familiarity with a programming tool such as MATLB, Python, or C++ is expected.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 and MATH 4100, and one of INFOTC 1040 or CMP_SC 1050, or CMP_SC 1300 or instructor's consent required

---

MATH 4310: Numerical Linear Algebra
(cross-leveled with MATH 7310). Solution of linear systems of equations by direct and iterative methods. Calculation of eigenvalues and eigenvectors of matrices. Selected algorithms programmed for solution on computers so familiarity with a programming tool such as MATLAB, Python, or C++ is expected.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 and MATH 4140, and one of INFOTC 1040 or CMP_SC 1050 or CMP_SC 1300 or instructor consent required

---

MATH 4315: Introduction to Mathematical Statistics
(same as STAT 4710; cross-leveled with MATH 7315, STAT 7710). Introduction to theory of probability and statistics using concepts and methods of calculus.

Credit Hours: 3
Prerequisites: MATH 2300 or instructor's consent

MATH 4320: Introduction to Probability Theory
(same as STAT 4750; cross-leveled with MATH 7320, STAT 7750). Probability spaces; random variables and their distributions; repeated trials; probability limit theorems.

Credit Hours: 3
Prerequisites: MATH 2300 or instructor's consent

MATH 4330: Theory of Numbers
(cross-leveled with MATH 7330). Divisibility, factorization, arithmetic functions, means value theorems, distribution of prime numbers, congruences, primitive roots, character theory, Riemann zeta function, and Dirichlet L-functions.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300. Recommended MATH 2320

MATH 4350: Introduction to Non-Euclidean Geometry
(cross-leveled with MATH 4350). Account of rise, development of non-Euclidean geometries. Intensive study of plane hyperbolic geometry.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 4355: Quantitative Finance and Insurance I
(cross-leveled with MATH 7355). This course introduces mathematical tools and methods for financial and insurance modeling. Special quantitative techniques including statistical and stochastic techniques like continuous and discrete distribution theories that geared towards finance and insurance applications are covered. Most of the contents of this course are listed in the Society Of Actuaries (SOA) - FAM examination website.

Credit Hours: 3
Prerequisites: Grade of C- or higher in STAT 4710 or MATH 4315 or STAT 4760 or MATH 4520

MATH 4355H: Quantitative Finance and Insurance I - Honors
(cross-leveled with MATH 7355). This course introduces mathematical tools and methods for financial and insurance modeling. Special quantitative techniques including statistical and stochastic techniques like continuous and discrete distribution theories that geared towards finance and insurance applications are covered. Most of the contents of this course are listed in the Society Of Actuaries (SOA) - FAM examination website.

Credit Hours: 3
Prerequisites: Grade of C- or higher in STAT 4710 or MATH 4315 or STAT 4760 or MATH 4520; honors eligibility required

---

MATH 4370: Interest Theory
(cross-leveled with MATH 7370). This course covers the concepts underlying the theory of interest and their applications to valuation of various cash flows, annuities certain, bonds, and loan repayment. This course is designed to help students prepare for Society of Actuaries exam FM (Financial Mathematics). It is oriented towards problem solving techniques applied to real-life situations and illustrated with previous exam problems.

Credit Hours: 3
Prerequisites: grade of C-or better in MATH 2300

MATH 4371: Models for Life Contingencies I
(cross-leveled with MATH 7371). The sequence MATH 4371 - MATH 4372 is designed to help students prepare for the Society of Actuaries exam LTAM (Long-Term Actuarial Mathematics). This course teaches the basic theory of life contingent actuarial models and the applications of those models to insurance and other financial risks. Covered topics include: survival models, life tables and selection, insurance benefits, life annuities, premium calculation and reserves.

Credit Hours: 3
Prerequisites: MATH 4320 or STAT 4750, and MATH 4370

MATH 4372: Models for Life Contingencies II
(cross-leveled with MATH 7372). The sequence MATH 4371 - MATH 4372 is designed to help students prepare for the Society of Actuaries exam LTAM (Long-Term Actuarial Mathematics). This course extends the life-death contingency models of Math 4371 to more general multiple-state and multiple-life models applied to problems involving a wide range of insurance and pension benefits. Covered topics include: Markov chains, multiple decrement models, joint life and last survivor benefits, pension mathematics, profit testing.

Credit Hours: 3
Prerequisites: A grade of C- or better in MATH 4371

MATH 4400: Introduction to Topology
(cross-leveled with MATH 7400). Topics from topology of Euclidean spaces, generalizations to metric spaces and topological spaces. Fundamentals of point set topology. Proficiency with sets, logic, and proofs (at the level of Math 3000) is recommended.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 4500: Applied Analysis
(cross-leveled with MATH 7500). Solution of the standard partial differential equations (wave, heat, Laplace's eq.) by separation of variables and transform methods; including eigenfunction expansions, Fourier and Laplace transform. Boundary value problems, Sturm-Liouville theory, orthogonality, Fourier, Bessel, and Legendre series, spherical harmonics.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 4100

MATH 4510: Higher Algebra
(cross-leveled with MATH 7510). An introduction to elementary number theory, modular arithmetic, rings of polynomials, fields, and group theory.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 or MATH 2320. Enrollment is restricted to students in the College of Education

---

MATH 4520: Statistical Inference I
(same as STAT 4760; cross-leveled with MATH 7520, STAT 7760). Sampling; point estimation; sampling distribution; tests of hypotheses; regression and linear hypotheses.

Credit Hours: 3
Prerequisites: MATH 4320

MATH 4525: Probability and Computing
(same as CMP_SC 4525; cross-leveled with MATH 7525, CMP_SC 7525) This course is concerned with probabilistic methods in computer science and discrete mathematics. Its goal is to study the interplay between probability and computational complexity, and to demonstrate

how tools from modern probability theory can be exploited in the study of structures that depend on many parameters, such as networks with many nodes and functions of many variables. Covered topics may include: discrete probability, concentration inequalities, martingale methods, the probabilistic method, entropy and information, Vapnik-Chervonenkis theory. Applications to (theoretical) computer science, combinatorics, random graphs, randomized algorithms, probabilistic analysis, derandomization. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 2320 or MATH 3000W; STAT 4710/STAT 7710 or STAT 4750/STAT 7750
Recommended: MATH 4120/MATH 7120; MATH 4140/MATH 7140

MATH 4540: Mathematical Modeling I
(cross-leveled with MATH 7540, ECE 7560, CMP_SC 7560). Solution of problems from industry, physical, social and life sciences, economics, and engineering using mathematical models.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 and MATH 4100
Recommended: Familiarity with software such as MATHEMATICA, MATLAB, or MAPLE

MATH 4560: Nonlinear Dynamics, Fractals and Chaos
(cross-leveled with MATH 7560). Conceptual introduction to nonlinear dynamics, bifurcation and stability of steady states, chaos in nonlinear differential equations and maps, fractal dimension, strange attractors, and applications to physical science.

Credit Hours: 3
Prerequisites: MATH 4100 or MATH 7100, MATH 4140 or MATH 7140, and familiarity with software such as MATHEMATICA, MATLAB, or MAPLE

MATH 4590: Quantitative Finance and Insurance II
(cross-leveled with MATH 7590). This course is a continuation of MATH 4355. The nature of this course is more theoretical and analytical. Appropriate mathematical foundations and interpretations of insurance risk models, Black-Scholes pricing formulas, and options and hedging theories, are covered. This course is recommended for actuarial science students.

Credit Hours: 3
Prerequisites: MATH 4355

MATH 4590H: Mathematics of Financial Derivatives II - Honors
(cross-leveled with MATH 7590). Binomial and Black-Scholes pricing models.Option Greeks, delta and gamma hedging, market maker profit theory. Asian, barrier, compound gap and exchange options. Lognormal and Monte Carlo price simulation. Geometric Brownian Motion and Ito's Lemma. Interest rate models and volatility.

Credit Hours: 3
Prerequisites: MATH 2300 and either STAT 2500 or STAT 4710 or MATH 4315; Honors eligibility required
Recommended: MATH 4355

MATH 4700: Advanced Calculus of One Real Variable I
(cross-leveled with MATH 7700). Basic topology of the real line, numerical sequences and series, continuity, differentiability, Riemann integration, uniform convergence, power series.

Credit Hours: 3
Prerequisites: Grade of C - or higher in MATH 3000

MATH 4720: Introduction to Abstract Algebra I
(cross-leveled with MATH 7720). Basic properties of integers, fundamental theorem of arithmetic, introduction to groups, rings and fields.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 3000

MATH 4900: Advanced Multivariable Calculus
(cross-leveled with MATH 7900). This is a course in calculus in several variables. The following is core material: Basic topology of n-dimensional Euclidian space; limits and continuity of functions; the derivative as a linear transformation; Taylor's formula with remainder; the Inverse and Implicit Function Theorems, change of coordinates; integration (including transformation of integrals under changes of coordinates); Green's Theorem. Additional material from the calculus of several variables may be included, such as Lagrange multipliers, differential forms, etc.

Credit Hours: 3
Prerequisites: MATH 4700

MATH 4920: Introduction to Abstract Linear Algebra
(cross-leveled with MATH 7920). Study of vector spaces over arbitrary fields: topics include linear maps on finite dimensional vector spaces, bilinear and multi-linear forms, invariant subspaces and canonical forms.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 4720

MATH 4940: Introduction to Complex Variables
(cross-leveled with MATH 7940). Complex functions, contour integration, power series, residues and poles, conformal mapping.

Credit Hours: 3
Prerequisites: MATH 4110 or MATH 4700

MATH 4960: Special Readings in Mathematics
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester.

Credit Hour: 1-3
Prerequisites: Consent of Department required

MATH 4996: Honors in Mathematics
Special work for senior B.A. Honors and B.S. Honors candidates.

Credit Hours: 2
Prerequisites: Consent of Department required

MATH 7001: Topics in Mathematics-General
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester.

Credit Hour: 1-99
Prerequisites: graduate standing and MATH 2300 and instructor's consent. Departmental consent for repetition

---

MATH 7060: Connecting Geometry to Middle and Secondary Schools
(cross-leveled with MATH 4060). Euclidean foundations, logic, Euler characteristic, congruence, area, Pick's Theorem, volume, Cavalieri's Principle, surface area, similarity, symmetry, transformations, matrices, and an introduction to spherical geometry.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1360 or MATH 1500. Enrollment is restricted to students in the College of Education

---

MATH 7070: Connecting Algebra to Middle and Secondary Schools
(cross-leveled with MATH 4070). A detailed study of integer and rational arithmetic and algebra. Topics include the Binomial Theorem, mathematical induction, division algorithm, Euclid's Algorithm, Fundamental Theorem of Arithmetic, Pythagorean triples, modular arithmetic and generalizations to polynomials, matrices and other axiomatic structures.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1400 or MATH 1500. Enrollment is restricted to students in the College of Education

---

MATH 7100: Differential Equations
(cross-leveled with MATH 4100). Traditional introductory course in ordinary differential equations. Includes 1st and 2nd order linear differential equations with numerous applications; Laplace transforms; power series solutions; numerical methods, linear systems.

Credit Hours: 3
Prerequisites: graduate standing and MATH 2300

MATH 7120: Graph Theory and Combinatorics
(cross-leveled with MATH 4120).This course provides an introduction to graph theory and related topics in combinatorics. Topics include counting spanning trees, colorings of graphs and chromatic polynomials, matchings, network flows, and planar graphs.

Credit Hours: 3
Prerequisites: MATH 2320 or MATH 3000 or instructor's consent

---

MATH 7140: Matrix Theory
(cross-leveled with MATH 4140). Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

Credit Hours: 3
Prerequisites: graduate standing and MATH 2300 or MATH 2320

MATH 7150: History of Mathematics
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored.

Credit Hours: 3
Prerequisites or Corequisites: MATH 2300 or MATH 2340

MATH 7300: Numerical Analysis
(cross-leveled with MATH 4300). Machine arithmetic, approximation and interpolation, numerical differentiation and integration, nonlinear equations, linear systems, differential equations, error analysis. Selected algorithms will be programmed for solution on computers so familiarity with a programming tool such as MATLB, Python, or C++ is expected.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 and MATH 4100, and one of INFOTC 1040 or CMP_SC 1050, or CMP_SC 1300 or instructor's consent required

---

MATH 7310: Numerical Linear Algebra
(cross-leveled with MATH 4310). Solution of linear systems of equations by direct and iterative methods. Calculation of eigenvalues and eigenvectors of matrices. Selected algorithms programmed for solution on computers so familiarity with a programming tool such as MATLAB, Python, or C++ is expected.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 and MATH 4140, and one of INFOTC 1040 or CMP_SC 1050 or CMP_SC 1300 or instructor's consent required

MATH 7330: Theory of Numbers
(cross-leveled with MATH 4330). Divisibility, factorization, arithmetic functions, means value theorems, distribution of prime numbers, congruences, primitive roots, character theory, Riemann zeta function, and Dirichlet L-functions.

Credit Hours: 3
Prerequisites: MATH 2300; recommended MATH 2320 or MATH 2340, and MATH 4940 or MATH 7940

MATH 7350: Introduction to Non-Euclidean Geometry
(cross-leveled with MATH 4350). Account of rise, development of non-Euclidean geometries. Intensive study of plane hyperbolic geometry.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 7355: Quantitative Finance and Insurance I
(cross-leveled with MATH 4355). This course introduces mathematical tools and methods for financial and insurance modeling. Special quantitative techniques including statistical and stochastic techniques like continuous and discrete distribution theories that geared towards finance and insurance applications are covered. Most of the contents of this course are listed in the Society Of Actuaries (SOA) - FAM examination website.

Credit Hours: 3
Prerequisites: Grade of C- in STAT 4710 or MATH 4315 or STAT 4760 or MATH 4520 or STAT 7710 or STAT 7760, or instructor's consent

MATH 7370: Interest Theory
(cross-leveled with MATH 4370). This course covers the main probability tools applied to financial risk modeling, and the financial mathematics concepts used in calculating present and accumulated values for various cash flows. It is a helpful tool in preparing for the Society of Actuaries exams P (Probability) and FM (Financial Mathematics), and it is oriented towards problem solving techniques illustrated with previous exam problems. Students are encouraged to take MATH 4355 prior to this course.

Credit Hours: 3
Prerequisites: MATH 2300, MATH 4320/ STAT 4750

MATH 7371: Models for Life Contingencies I
(cross-leveled with MATH 4371). The sequence MATH 4371 - MATH 4372 is designed to help students prepare for the Society of Actuaries exam LTAM (Long-Term Actuarial Mathematics). This course teaches the basic theory of life contingent actuarial models and the applications of those models to insurance and other financial risks. Covered topics include: survival models, life tables and selection, insurance benefits, life annuities, premium calculation and reserves.

Credit Hours: 3
Prerequisites: MATH 4370 or MATH 7370

MATH 7372: Models for Life Contingencies II
(cross-leveled with MATH 4372). The sequence MATH 4371 - MATH 4372 is designed to help students prepare for the Society of Actuaries exam LTAM (Long-Term Actuarial Mathematics). This course extends the life-death contingency models of MATH 4371 to more general multiple-state and multiple-life models applied to problems involving a wide range of insurance and pension benefits. Covered topics include: Markov chains, multiple decrement models, joint life and last survivor benefits, pension mathematics, profit testing.

Credit Hours: 3
Prerequisites: A grade of C- or better in MATH 4371 or MATH 7371

MATH 7400: Introduction to Topology
(cross-leveled with MATH 4400). Topics from topology of Euclidean spaces, generalizations to metric spaces and topological spaces. Fundamentals of point set topology. Proficiency with sets, logic, and proofs (at the level of Math 3000) is recommended.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 7500: Applied Analysis
(cross-leveled with MATH 4500). Solution of the standard partial differential equations (wave, heat, Laplace's eq.) by separation of variables and transform methods; including eigenfunction expansions, Fourier and Laplace transform. Boundary value problems, Sturm-Liouville theory, orthogonality, Fourier, Bessel, and Legendre series, spherical harmonics.

Credit Hours: 3
Prerequisites: MATH 4100/ MATH 7100

MATH 7510: Higher Algebra
(cross-leveled with MATH 4510). An introduction to elementary number theory, modular arithmetic, rings of polynomials, fields, and group theory.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 or MATH 2320. Enrollment is restricted to students in the College of Education

MATH 7525: Probability and Computing
(same as CMP_SC 7525; cross-leveled with CMP_SC 4525, MATH 4525). This course is concerned with probabilistic methods in computer science and discrete mathematics. Its goal is to study the interplay

between probability and computational complexity, and to demonstrate how tools from modern probability theory can be exploited in the study of structures that depend on many parameters, such as networks with many nodes and functions of many variables. Covered topics may include: discrete probability, concentration inequalities, martingale methods, the probabilistic method, entropy and information, Vapnik-Chervonenkis theory. Applications to (theoretical) computer science, combinatorics, random graphs, randomized algorithms, probabilistic analysis, derandomization. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 2320 or MATH 3000W; STAT 4710/STAT 7710 or STAT 4750/STAT 7750
Recommended: MATH 4120/MATH 7120, MATH 4140/MATH 7140

MATH 7540: Mathematical Modeling I
(same as ECE 7560, CMP_SC 7560; cross-leveled with MATH 4540). Solution of problems from industry, physical, social and life sciences, economics, and engineering using mathematical models.

Credit Hours: 3
Prerequisites: graduate standing and 3 semesters of calculus and some exposure to ordinary differential equations or instructor's consent

---

MATH 7560: Nonlinear Dynamics, Chaos and Fractals
(cross-leveled with MATH 4560). Conceptual introduction to nonlinear dynamics, bifurcation and stability of steady states, chaos in nonlinear differential equations and maps, fractal dimension, strange attractors, and applications to physical science.

Credit Hours: 3
Prerequisites: graduate standing and MATH 4100/ MATH 7100, MATH 4140/ MATH 7140, and familiarity with software such as MATHEMATICA, MATLAB, or MAPLE

MATH 7590: Quantitative Finance and Insurance II
(cross-leveled with MATH 4590). This course is a continuation of Math 7355. The nature of this course is more theoretical and analytical. Appropriate mathematical foundations and interpretations of insurance risk models, Black-Scholes pricing formulas, and options and hedging theories, are covered. This course is recommended for actuarial science students.

Credit Hours: 3
Prerequisites: MATH 4355 or MATH 7355

MATH 7700: Advanced Calculus of One Real Variable I
(cross-leveled with MATH 4700). Series of real numbers, limits of functions, continuity and uniform continuity, differentiability, and Riemann integration.

Credit Hours: 3
Prerequisites: Consent of the Department
Recommended: MATH 4140 and one other mathematics course number above MATH 2300

MATH 7720: Introduction to Abstract Algebra I
(cross-leveled with MATH 4720). Basic properties of integers, fundamental theorem of arithmetic, introduction to groups, rings and fields.

Credit Hours: 3
Prerequisites: Consent of Department required
Recommended: MATH 4140 and one other Mathematics course numbered above 2300

MATH 7900: Advanced Multivariable Calculus
(cross-leveled with MATH 4900). This is a course in calculus in several variables. The following is core material: Basic topology of n-dimensional Euclidian space; limits and continuity of functions; the derivative as a linear transformation; Taylor's formula with remainder; the Inverse and Implicit Function Theorems, change of coordinates; integration (including transformation of integrals under changes of coordinates); Green's Theorem. Additional material from the calculus of several variables may be included, such as Lagrange multipliers, differential forms, etc.

Credit Hours: 3
Prerequisites: MATH 4700/ MATH 7700

MATH 7920: Introduction to Abstract Linear Algebra
(cross-leveled with MATH 4920). Study of vector spaces over arbitrary fields: topics include linear maps on finite dimensional vector spaces, bilinear and multi-linear forms, invariant subspaces and canonical forms.

Credit Hours: 3
Prerequisites: MATH 4720 or MATH 7720

MATH 7940: Introduction to Complex Variables
(cross-leveled with MATH 4940). Complex functions, contour integration, power series, residues and poles, conformal mapping.

Credit Hours: 3
Prerequisites: MATH 4110/ MATH 7110 OR MATH 4700/ MATH 7700

MATH 7960: Special Readings in Mathematics

Credit Hour: 1-3
Prerequisites: MATH 2300 and instructor's consent

MATH 7980: Mathematics Problem Solving
Creative advanced problem solving bringing together methods such as integration, probability and Euclidean geometry.

Credit Hours: 3
Prerequisites: MATH 4140 and another 4000 level Mathematics course, or instructor's consent

---

MATH 8085: Problems in Mathematics
Problems in Mathematics

Credit Hours: 3

MATH 8090: Master's Thesis Research in Mathematics
Students will be required to complete an independent project. Topics are chosen in consultation with a faculty advisor and are subject to departmental consent. Graded on S/U basis only.

Credit Hours: 3

MATH 8102: Topics in Algebra
Advanced topics in algebra.

Credit Hours: 3
Prerequisites: MATH 8410

MATH 8190: Masters Project in Mathematics
Masters Project in Mathematics

Credit Hours: 3

MATH 8202: Topics in Functional Analysis
Topics in Functional Analysis

Credit Hours: 3

MATH 8210: Basic Algebra
Accelerated problem solving course in linear and abstract algebra. Will prepare students for the algebra qualifying exam.

Credit Hours: 3
Prerequisites: MATH 4720, MATH 4920, or instructor's consent, or equivalent
Corequisites: MATH 8220 and MATH 8250

MATH 8220: Basic Analysis
Accelerated problem-solving course in advanced calculus and complex analysis. Will prepare students for the analysis qualifying exam.

Credit Hours: 6
Prerequisites: MATH 4700, MATH 4900, MATH 4940, instructor's consent or equivalent

---

MATH 8250: Basic Topology and Geometry
Topological spaces, differential manifolds, differential forms, integration of vector fields.

Credit Hours: 3
Prerequisites: MATH 4700, MATH 4900, MATH 4140, or instructor's consent, or equivalent
Corequisites: MATH 8210 and MATH 8220

MATH 8302: Topics in Harmonic Analysis
Topics in Harmonic Analysis

Credit Hours: 3

MATH 8402: Topics in Mathematical Physics
Topics in Mathematical Physics

Credit Hours: 3

MATH 8410: Algebra I
Theory of algebraic structures--groups, rings, fields, algebraic and transcendental extensions of fields.

Credit Hours: 3
Prerequisites: MATH 4720 and MATH 4920, or equivalent

MATH 8411: Algebra II
Theory of modules, Galois theory and additional topics to be selected by the instructor.

Credit Hours: 3
Prerequisites: MATH 8410 or equivalent

MATH 8420: Theory of Functions of Real Variables I
Properties of functions of one real variable. Lebesgue measure and integration on the line.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 and MATH 4900 or MATH 7900, or equivalent

---

MATH 8421: Theory of Functions of Real Variables II
Continuation of MATH 8420. General measure and integration theory. Elements of the theory of Hilbert and Banach spaces, linear functions and linear operators.

Credit Hours: 3
Prerequisites: MATH 8420

MATH 8425: Complex Analysis I
Rigorous introduction to the theory of functions of a complex variable.

Credit Hours: 3
Prerequisites: MATH 4940 or MATH 7940 or equivalent

MATH 8426: Complex Analysis II
Analytic continuation, Riemann surfaces, entire and meromorphic functions, selected topics.

Credit Hours: 3
Prerequisites: MATH 8425

MATH 8430: Differentiable Manifolds
This course is about calculus in very general settings, which may include curved spaces and abstractly defined spaces. Its origins go back to attempts to make maps of the Earth taking into account its curvature; its modern applications include mechanics, dynamical systems, partial differential equations, and most famously Einstein's theory of gravity.

Credit Hours: 3
Prerequisites: MATH 7920 or equivalent; MATH 7900 or equivalent; MATH 8655 or equivalent

---

MATH 8440: Advanced Ordinary Differential Equations I
Topics from existence and uniqueness theorems, plane autonomous systems, periodicity and boundedness of solutions of second order nonlinear equations, perturbation theory, Sturm-Liouville systems, behavior of solutions at singularities.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or equivalent

MATH 8445: Partial Differential Equations I
Fourier and integral transforms, first and second order partial differential equations, methods of characteristics, Laplace's equation, Direchlet and Neumann problems, Green's functions and maximum principles.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or instructor's consent required

---

MATH 8446: Partial Differential Equations II
The Cauchy-Kovalevski theorem, the Lewy example, the heat operator, the wave operator, Sobolev spaces, local regularity of elliptic boundary value problems.

Credit Hours: 3
Prerequisites: MATH 8445
Recommended: MATH 8420

MATH 8460: Mathematical Finance I
Financial instruments and derivative: stocks, bonds, futures option prices on interest rates, swaps, etc. Mathematical models of stock price fluctuations. Interest rates and options on interest rates. Swaps. Open markets and properties of stock option prices. Stochastic models. Bionomial trees. Continuous time stochastic modeling. No arbitrage modeling. European and American options. BlackScholes model and differential equation, for the price of European option. Exotic options. Interest rate models.

Credit Hours: 3
Prerequisites: graduate standing in Mathematics. Knowledge of elementary probability or instructor's consent

---

MATH 8461: Mathematical Finance II
Diffusion Processes as models for stock price fluctuations. Contingent claims and arbitrage. Mathematical analysis of risk neutral valuation of contingent claims. Self-financing portfolios and hedging. Hedging contingent claims. Partial differential equations for valuation of derivative securities. Completeness of the markets and hedging. Parity relations and delta hedging. Several underlying assets.

Credit Hours: 3
Prerequisites: knowledge of advance probability/stochastic processes or instructor's consent
Recommended: MATH 8460

MATH 8480: Advanced Probability
(same as STAT 9810). Measure theoretic probability theory. Characteristic functions; conditional probability and expectation; sums of independent random variables including strong law of large numbers and central limit problem.

Credit Hours: 3
Prerequisites: MATH 4320 or MATH 8220; or instructor's consent

---

MATH 8502: Topics of Geometry
Topics of Geometry.

Credit Hours: 3
Prerequisites: instructor's consent

MATH 8510: Commutative Algebra I
This course deals with fundamentals and basic techniques of Commutative Algebra. This can be a good introduction to Algebraic Geometry and Algebraic Number theory. The course begins with Rings, Ideals, Modules, Localization. Homological Algebra with concepts leading to Flatness, Dimension, Depth, Ascending and Descending Chain Conditions and Completion would be some of the typical material covered in this course, although other topics may be introduced as well. Topics such as Cohen-Macaulay Rings, Normal Rings, Regular Rings, Gorenstein Rings, Noether Normalization, Primary Decomposition, etc. may be covered if time permits or will be continued in the second part of the course.

Credit Hours: 3
Prerequisites: MATH 8410 and MATH 8411 or equivalent

MATH 8511: Commutative Algebra II
This course is a continuation of Commutative Algebra I. Basic concepts of Commutative Algebra will be assumed. In general, topics such as Cohen Macaulay rings, regularity, depth conditions and completion may be introduced as necessary. This can be a good introduction to Algebraic Geometry and Algebraic Number theory as well as starting research in commutative algebra.

Credit Hours: 3
Prerequisites: MATH 8410, MATH 8411, and MATH 8510 or instructor's consent

---

MATH 8520: Analytic Number Theory
This is a first course in analytic number theory at the graduate level. The course covers standard applications of real and complex analysis to the theory of numbers. Some prior experience with basic number theory and with analysis is highly recommended. The object of the course is to understand the numerous ways in which analytic techniques have been brought to bear on the study of numbers.

Credit Hours: 3
Prerequisites: MATH 4330/MATH 7330 and MATH 4940/MATH 7940, or equivalent

---

MATH 8521: Algebraic Number Theory
This is a first course in algebraic number theory at the graduate level. But be careful! A large part of number theory (especially algebraic number theory) is not about numbers, but rather about more abstract concepts which have their origins in problems about numbers. The main object for the course is to learn various concepts and theorems necessary to understand the main theorems of both local and global class field theory.

Credit Hours: 3
Prerequisites: MATH 8410 and MATH 8411 or equivalent

MATH 8587: Topology Seminar
Topology Seminar

Credit Hours: 3

MATH 8602: Topics in Financial Mathematics and Insurance
Topics in Financial Mathematics and Insurance

Credit Hours: 3

MATH 8615: Algebraic Geometry I
Affine and projective varieties and schemes; nullstellensatz; Zariski topology, morphisms and rational maps; divisors and linear systems; topics from curves, surfaces, Grassmann varieties; commutative algebra and homological algebra as needed.

Credit Hours: 3
Prerequisites: MATH 8410

MATH 8616: Algebraic Geometry II
Continuation of MATH 8615.

Credit Hours: 3
Prerequisites: MATH 8615

MATH 8618: Introduction to Algebraic Topology
Development of singular homology theory; reference to other homology and cohomology theories. Introduction to homological algebra.

Credit Hours: 3
Prerequisites: MATH 8250

MATH 8628: Functional Analysis I
Linear topological spaces, Banach spaces, Hilbert spaces. Operator theory, including the Hahn-Banach, uniform boundedness and closed graph theorems.

Credit Hours: 3
Prerequisites: MATH 4900 and instructor's consent or MATH 8420

MATH 8630: Harmonic Analysis I
An introduction to Fourier Analysis in one and higher Dimensions. Topics include Fourier Series, conjugate functions, Fourier transforms, distributions, interpolation, and maximal functions.

Credit Hours: 3
Prerequisites: MATH 8420

MATH 8631: Harmonic Analysis II
Singular integrals, Littlewood-Paley theory, Hardy spaces, bounded mean oscillation, weighted norm inequalities, boundary value problems, and analysis on groups.

Credit Hours: 3
Prerequisites: MATH 8630

MATH 8650: Differentiable Manifolds and Riemannian Geometry
Tensor product spaces and tensor fields on manifolds. Differentiation and integration of differential forms. Riemannian geometry and applications.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 4400

MATH 8655: General Topology I
Introduction to axiomatic theory of general topology. Continuous functions and homeomorphisms. Convergence in abstract topological spaces. Compact and locally compact spaces. Connectedness. Metrizable spaces.

Credit Hours: 3
Prerequisites: MATH 4900, MATH 4400 or instructor's consent

MATH 8702: Topics in Applied Mathematics
Selected topics in applied mathematics drawn from variety of areas: partial differential equations, tensor analysis, calculus of variations, asymptotic methods, integral equations, advanced theory of transforms and distributions, numerical analysis.

Credit Hours: 3

MATH 9090: Doctoral Dissertation Research in Mathematics
Doctoral Dissertation Research in Mathematics. Graded on a S/U basis only.

Credit Hour: 1-9

MATH 9387: Harmonic Analysis Seminar
Harmonic Analysis Seminar

Credit Hours: 3

MATH 9487: Mathematical Physics Seminar
Mathematical Physics Seminar

Credit Hours: 3

MATH 9502: Topics in Topology
Advanced topics in topology or topological algebra.

Credit Hours: 3

MATH 9702: Topics in Numerical Mathematics
Topics in Numerical Mathematics.

Credit Hours: 3
Prerequisites: instructor's consent

MATH 9787: Applied Mathematics Seminar
Applied Mathematics Seminar

Credit Hours: 3

MATH 9887: Analysis Seminar
Analysis Seminar

Credit Hours: 3