MATHEMATICAL SCIENCES (MATH)

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MATH 99 Problem-Solving Methods in Mathematics (0 Credit Hours)
This course offers a review of topics in arithmetic and basic algebra such as percentages, decimals, basic algebraic operations, equations, graphing, and elementary word problems.
Outcomes:
Students with weak backgrounds in basics mathematics will receive the preparation needed to enroll in Mathematics 100

MATH 100 Intermediate Algebra (3 Credit Hours)
This course covers the fundamentals of algebra, ranging from linear equations and their graphs through exponents and systems of equations.
Course equivalencies: ACMAT100/MATH100
Outcomes:
Students with weak algebraic backgrounds will receive the preparation needed to use algebra in other courses or, if they plan to take calculus, to enroll in College Algebra

MATH 108 Real World Modeling with Mathematics (3 Credit Hours)
This course investigates mathematical modeling applied to a variety of topics such as linear programming, coding information, probability and statistics, scheduling problems and social choice.
Knowledge Area: Quantitative Knowledge
Outcomes:
Students will understand the usefulness of mathematical modeling in a variety of disciplines within the life sciences, the social sciences, and business; This course satisfies the quantitative literacy requirement of the core curriculum

MATH 117 Precalculus I (3 Credit Hours)
Pre-requisites: Math Placement Test or MATH 100
This course covers algebraic topics ranging from functions and their applications to complex numbers to inverse functions to the fundamental theorem of algebra.
Course equivalencies: ACMAT 117/MATH 117
Outcomes:
Students who plan to study calculus will obtain the algebraic background needed to enroll in precalculus

MATH 118 Precalculus II (3 Credit Hours)
Pre-requisites: Math Placement Test or MATH 117
This course covers topics ranging from exponential and logarithmic functions to trigonometric functions to the complex plane and elementary optimization problems.
Course equivalencies: MATH 118/ ACMAT 118
Outcomes:
Students will obtain the background needed to enroll in either of the departments calculus sequences

MATH 123 Topics (1-3 Credit Hours)
Freshman Mathematics/Statistics Seminar (1-3 Credit Hours): A freshman seminar with no prerequisites on topics in the mathematical sciences drawn from algebra, geometry, statistics, and their applications.

MATH 131 Applied Calculus I (3 Credit Hours)
Pre-requisites: Math Placement Test or MATH 118
An introduction to differential and integral calculus, with an emphasis on applications. This course is intended for students in the life and social sciences, computer science, and business. Topics include: modeling change using functions including exponential and trigonometric functions, the concept of the derivative, computing the derivative, applications of the derivative to business and life, social and computer sciences, and an introduction to integration.
Interdisciplinary Option: Bioinformatics, Forensic Science
Outcomes:
Students will obtain an understanding of calculus and methods for applying calculus (especially differential calculus), including modeling/analyzing processes (such as population growth and cooling), interpreting the derivative (numerical, graphical, and algebraic), and optimization (such as finding the time and level for a peak drug concentration)

MATH 132 Applied Calculus II (3 Credit Hours)
Pre-requisites: MATH 131
This course is a continuation of MATH 131. Topics include: definition and interpretations of the integral (numerically, graphically, and algebraically), basic techniques for computing anti-derivatives, applications to probability, an introduction to multi-variable calculus and optimization for functions of several variables, and mathematical modeling using differential equations. (This course is not a substitute for MATH 162.)
Interdisciplinary Option: Bioinformatics, Forensic Science
Outcomes:
Students will obtain an understanding of integral and multi-variable calculus, including modeling/analyzing processes with the integral, optimization of functions of several variables, and modeling with differential equations

MATH 140L Geometry for Middle Grade Teachers (3 Credit Hours)
The content covered in this course will include: Area, perimeter, volume, surface area, Properties of two and three dimensional figures, points, lines, planes, space, the Pythagorean theorem, transformations, fractals, tessellations, perspective drawings and informal proofs. The material covered will address Illinois Learning Standard Goal 7 and Goal 9 and related content performance descriptors for educators. The course is designed for Elementary education majors that wish to enhance, enrich and deepen their knowledge of Geometry and apply for a 6th-8th grade Mathematics endorsement from the State of Illinois. Mathematics Content Area Standards 7 (Measurement) and 9 (Geometry) from the Content-Area Standards for Educators document published by the Illinois State Board of Education will be emphasized.
Outcomes:
Students will obtain an understanding of the geometry topics taught in the middle grade mathematics curriculum

MATH 141L Number Theory for Middle Grade Teachers (3 Credit Hours)
Greatest common divisors, prime factorization, decimal fractions, continued fractions, primes, composite numbers, tests for divisibility, perfect numbers, polygonal numbers, numbers bases, and patterns in addition and multiplication tables are a sample of the topics covered. (Illinois Learning Standard Goal 6 and related performance descriptors). Appropriate use of technology (spread sheets, CAS, etc.) will also be addressed.
Outcomes:
Students will obtain an understanding of topics from Number Theory that are addressed in the middle grade mathematics curriculum

MATH 142L History of Mathematics for Middle Grade Teachers (3 Credit Hours)
This course will provide a thematic approach to the history of mathematics with emphasis on contributions by noted mathematicians, mathematical societies and scientists highlighting women and under-represented populations. The history of numbers and numerals, computation, geometry, algebra, trigonometry, calculus, and science patterns will be explored emphasizing the contributions of the Babylonian, Egyptian, Chinese, and Roman civilizations as well as such individuals as Euclid, Fermat, Archimedes, Kepler, Pythagoras, Euler, Hypatia, Sonjs Kovalevsky, Emmy Noether and others as appropriate. The influence of technology and its applications will also be presented as appropriate.
Outcomes:
Students will obtain a unique historical perspective on the various areas of mathematics that are studied in the middle grade mathematics curriculum

MATH 143L Probability and Statistics for Middle Grade Teachers (3 Credit Hours)
Data collection and display, simulations, surveys, probability and elementary statistics such as mean, median, mode, standard deviation, etc. will be the focus of this course (Illinois Learning Standard Goal 10) Appropriate techniques for graphing (scatter plots, histograms, regression, correlation) with and without technology will be a focus of this course.
Outcomes:
Students will obtain a background in the fundamentals of descriptive and inferential statistics, along with an understanding of their uses and misuses, as addressed in middle school mathematics curriculum

MATH 147 Mathematics For Teachers I (3 Credit Hours)
For course description, see CIEP 104.
This course satisfies the Engaged Learning requirement.
Course equivalencies: X-CIEP104/MATH147

MATH 148 Mathematics For Teachers II (3 Credit Hours)
For course description, see CIEP 105.
Course equivalencies: X-CIEP105/MATH148

MATH 149 Intro to Computer Science For Teachers (3 Credit Hours)
For prerequisite and description, see COMP 120.
Course equivalencies: X-COMP120/MATH149

MATH 161 Calculus I (4 Credit Hours)
Pre-requisites: Math Placement Test or MATH 118
This course provides a standard introduction to differential and integral calculus and covers topics ranging from functions and limits to derivatives and their applications to definite and indefinite integrals and the fundamental theorem of calculus and their applications.
Interdisciplinary Option: Bioinformatics, Forensic Science
Course equivalencies: ACMAT 161/MATH 161
Outcomes:
Students will obtain the background needed to enroll in Calculus II

MATH 162 Calculus II (4 Credit Hours)
Pre-requisites: MATH 161
This course is a continuation of Calculus I and includes the calculus of various classes of functions, techniques of integration, applications of integral calculus, three-dimensional geometry, and differentiation and integration in two variables.
Interdisciplinary Option: Bioinformatics
Course equivalencies: ACMAT 162/MATH 162
Outcomes:
Students will obtain the background needed for further study in mathematics and to apply mathematics in the physical sciences

MATH 162A Calculus II, Alternate (4 Credit Hours)
Pre-requisites: MATH 161
This course is a continuation of Calculus I and includes the calculus of various classes of functions, techniques of integration, applications of integral calculus, sequences and infinite series, and an introduction to differential equations. This course follows a traditional approach to calculus sequencing.
Interdisciplinary Option: Bioinformatics
Outcomes:
Students will obtain the background needed for further study in mathematics and to apply mathematics in the physical sciences

MATH 170 Service Learning in Mathematics (3 Credit Hours)
Pre-requisites: B+ or higher in any of the following (MATH 118 or MATH 131 or MATH 132 or MATH 161 or MATH 162 or MATH 263 or MATH 263A)
Students will learn best practices to communicate mathematical concepts and skills to diverse populations by engaging in tutoring mathematics to the undergraduate population at Loyola. This course is designed to promote and encourage engagement and rigor in mathematical concepts and skills among the diverse communities of learners at Loyola.
This course satisfies the Engaged Learning requirement.
Outcomes:
Students in this course will deepen their understanding of mathematical concepts and skills and be able to communicate this effectively to diverse communities of learners

MATH 201 Introduction to Discrete Mathematics & Number Theory (3 Credit Hours)
This course covers topics from discrete mathematics and number theory, areas of mathematics not seen in calculus courses and abundant in applications, that provide students with the concepts and techniques of mathematical proof needed in 300 level courses in mathematics.
Outcomes:
Students will obtain an understanding of the basic concepts and techniques involved in constructing rigorous proofs of mathematical statements

MATH 212 Linear Algebra (3 Credit Hours)
Pre-requisites: MATH 132 or MATH 162 or MATH 162A
This course provides an introduction to linear algebra in abstract vector spaces with an emphasis on Rn, covering topics such as Gaussian elimination, matrix algebra, linear independence and spanning, linear transformations and eigenvalues; software packages such as MAPLE may be used.
Outcomes:
Students will receive an introduction to abstract mathematics in a setting that encourages the thinking needed in more advanced mathematics courses

MATH 215 Object-Oriented Programming with Mathematics (3 Credit Hours)
Pre-requisites: MATH 132 or MATH 162 or MATH 162A
This is an introductory programming course for students interested in mathematics and scientific computing. Students will program primarily in a general object-oriented language such as Python, with supplementary exercises in a computer algebra system. Examples will be drawn primarily from applications of calculus, elementary number theory, and cryptography.
Course equivalencies: X-COMP215/MATH215
Outcomes:
Students will learn basic scripting and object-oriented programming, with the goal of being able to solve mathematical and scientific problems

MATH 263 Multivariable Calculus (4 Credit Hours)
Pre-requisites: MATH 162
This course covers the differential and integral calculus of multivariable and vector valued functions, and sequences and infinite series, culminating with Green's Theorem, the Divergence Theorem, and Stokes' Theorem; software packages such as MAPLE may be used.
Outcomes:
Students will obtain an understanding of multivariable calculus and its applications, as well as background needed for the study of more advanced mathematics

MATH 263A Multivariable Calculus, Alternate (4 Credit Hours)
Pre-requisites: MATH 162A
This course covers the differential and integral calculus of multivariable and vector valued functions, culminating with Green's Theorem, the Divergence Theorem, and Stokes' Theorem; software packages such as MAPLE may be used. This course follows a traditional approach to calculus sequencing.
Outcomes:
Students will obtain an understanding of multivariable calculus and its applications, as well as background needed for the study of more advanced mathematics

MATH 264 Ordinary Differential Equations (3 Credit Hours)
Pre- or co-requisites: MATH 263 or MATH 263A
This course covers the theory, solution techniques, and applications surrounding linear and non-linear first and second-order differential equations, including systems of equations; software packages such as MAPLE may be used.
Outcomes:
Students will obtain an understanding of elementary differential equations and their applications

MATH 266 Differential Equations and Linear Algebra (3 Credit Hours)
Co-requisites: MATH 263 or MATH 263A
This course provides an introduction to basic topics in ordinary differential equations and linear algebra. Topics include first and second-order differential equations, Laplace transform, systems of first-order differential equations, systems of linear algebraic equations, matrix algebra, bases and dimension for vector spaces, linear independence, linear transformations, determinants, eigenvalues, and eigenvectors. Prerequisites or
Outcomes:
Students will learn fundamental results and methods in ordinary differential equations and linear algebra, with a strong emphasis on topics that are particularly relevant for Engineering Science

MATH 277 Problem-Solving Seminar (1 Credit Hour)
In a seminar setting, students discuss and present proofs (or computer examples) as solutions to regional and national mathematics contest problems usually involving techniques drawn from elementary logic, calculus of one and several variables, combinatorics, number theory, geometry, basic algebra, and abstract algebra. Learning Outcome: To improve a student's ability to communicate mathematically and to strengthen the student's problem-solving skills.

MATH 298 Mathematics Seminar (1-3 Credit Hours)
This course is a sophomore-level seminar covering topics in areas such as number theory, logic, set theory, metric spaces, or history of mathematics.
Outcomes:
Students will obtain an initial insight into a number of areas of advanced study in mathematics

MATH 301 History of Mathematics (3 Credit Hours)
Pre-requisites: MATH 132 or MATH 162 or MATH 162A
This course explores selected topics in the history of mathematics ranging from Babylonian and Egyptian mathematics to Pythagoras and Euclid to the Hindu-Arabic numeration system to Newton and Leibniz to geometries other that Euclid's to the mathematical art of Escher.
Outcomes:
Students will obtain a unique historical perspective on the various areas of mathematics that they are studying in their other courses

MATH 304 Introduction to Probability (3 Credit Hours)
For prerequisites and description, see STAT 304.
Course equivalencies: X-MATH304/STAT304

MATH 305 Introduction to Mathematical Statistics (3 Credit Hours)
For prerequisites and description, see STAT 305.
Course equivalencies: X-MATH305/STAT305

MATH 306 Intro to Stochastic Processes (3 Credit Hours)
For prerequisites and description, see STAT 306.
Course equivalencies: X-MATH306/STAT306

MATH 309 Numerical Methods (3 Credit Hours)
Pre-requisites: (COMP 170 or COMP 215) and [(MATH 212 and 264) or MATH 266]
This course offers an introduction to topics such as error analysis, interpolation and approximation, and the numerical solution of problems involving differentiation, integration, and ordinary and partial differential equations.
Course equivalencies: X-COMP309/MATH309
Outcomes:
Students will obtain an understanding of how numerical methods can be used in a variety of areas of mathematics

MATH 313 Abstract Algebra (3 Credit Hours)
Pre-requisites: MATH 201 and 212
This course provides a rigorous introduction to the study of structures such as groups, rings, and fields; emphasis is on the theory of groups with topics such as subgroups, cyclic groups, Abelian groups, permutation groups, homomorphisms, cosets, and factor groups.
Outcomes:
Students will obtain an understanding of abstract structures that will prepare them for advanced work in mathematics

MATH 314 Advanced Topics Abstract Algebra (3 Credit Hours)
Pre-requisites: MATH 313
This course studies advanced algebraic systems such as commutative and non-commutative rings, integral domains, fields, and additional selected topics.
Outcomes:
Students will obtain an understanding of advanced abstract structures that will prepare them for graduate level work in mathematics

MATH 315 Advanced Topics in Linear Algebra (3 Credit Hours)
Pre-requisites: MATH 313
This course offers a rigorous abstract approach to vector spaces and transformations, including similarity, duality, canonical forms, inner products, bilinear forms, Hermitian and unitary spaces, and other selected topics.
Outcomes:
Students will obtain an understanding of advanced linear algebra structures that will prepare them for graduate level work in mathematics

MATH 318 Combinatorics (3 Credit Hours)
Pre-requisites: MATH 162 or MATH 162A
This course offers a rigorous introduction to combinatorics, including topics such as induction, the pigeon-hole principle, permutations, combinations, recurrence relations, generating functions, the inclusion-exclusion principle, and other selected topics.
Outcomes:
Students will obtain an understanding of the basic topics in combinatorics that will prepare them for advanced study of related topics in mathematics and computer science

MATH 320 Mathematical Logic (3 Credit Hours)
Pre-requisites: MATH 201
This course in modern mathematical logic begins with a study of propositional logic and leads to the study of first-order predicate logic, including quantifiers, models, syntax, semantics, the completeness and compactness theorems, and other selected topics.
Outcomes:
Students will develop a fuller understanding of mathematical logic and therefore of the underlying theory behind proofs of mathematical assertions

MATH 322 Advanced Number Theory (3 Credit Hours)
Pre-requisites: MATH 201
This course will cover Pythagorean triples, problems related to Fermat's Last Theorem, Pell's equation, Fermat's method of descent, primes in arithmetic progressions, Mersenne primes, perfect numbers, primitive roots, primality testing, Carmichael numbers, RSA public key encryption, quadratic residues, and quadratic reciprocity. Additional topics will be covered as time permits.
Outcomes:
Students will be able to solve important practical and theoretical number theory problems; Students will be exposed to both significant recently solved number theory problems and currently unsolved conjectures

MATH 328 Algebraic Coding Theory (3 Credit Hours)
Pre-requisites: MATH 212 or MATH 266
Codes with algebraic structure for error control are examined. Block codes including Hamming codes and Reed-Muller codes, BCH codes, and other cyclic codes and their implementation are treated. Other topics may include: convolutional codes, efficiency considerations, and Shannon's fundamental theorem of information theory.
Course equivalencies: X-MATH328/COMP328

MATH 331 Cryptography (3 Credit Hours)
Pre-requisites: Theoretical Foundations: MATH201 or COMP363; Programming Foundations: COMP125 or COMP150 or COMP170 or COMP/MATH 215
This course introduces the formal foundations of cryptography and also investigates some well-known standards and protocols, including private and public key cryptosystems, hashing, digital signatures, RSA, DSS, PGP, and related topics.
Course equivalencies: X-COMP331/MATH331
Outcomes:
Students will gain an understanding of cryptosystems widely used to protect data security on the internet, and be able to apply the ideas in new situations as needed

MATH 344 Geometry (3 Credit Hours)
Pre-requisites: MATH 212
This course discusses axiomatic systems which define geometries and includes topics from synthetic and analytic projective geometry.
Outcomes:
Students will obtain an understanding of the many different geometries that are studied by teachers and researchers

MATH 345 Introduction to Financial Mathematics Derivatives (3 Credit Hours)
Pre-requisites: (MATH 264 or MATH 266) and MATH 304
The course provides an introduction to the mathematical theory of option pricing. We will rigorously derive option relationships using no arbitrage conditions, introduce rudimentary stochastic calculus and Brownian motion as models for stock prices, and give an introduction to methods for solving partial differential equations to give explicit Black-Scholes formulas.
Outcomes:
The students will gain knowledge of the theory of options, bond and stock pricing, portfolio optimization, and will be exposed to other relevant applications of Mathematics to Finance

MATH 351 Introduction to Real Analysis I (3 Credit Hours)
Pre-requisites: MATH 201 and MATH 263 and (MATH 212 or MATH 266)
This course provides a rigorous treatment of the real numbers and real-valued functions of a real variable, including sequences, the Bolzano-Weierstrass and Heine-Borel theorems, topology, uniform continuity, fixed-point theorems, derivatives, and other selected topics.
Outcomes:
Students will obtain an understanding of the fundamentals of real analysis that will prepare them for advanced work in mathematics

MATH 352 Introduction to Real Analysis II (3 Credit Hours)
Pre-requisites: MATH 351
This course, a continuation of MATH 351, provides the theoretical background for differentiability and integrability on R and Rn and Taylor's theorem, the change of variable theorem, the inverse and implicit function theorems, Lebesgue integration, and other selected topics.
Outcomes:
Students will obtain an understanding of topics in advanced analysis that will prepare them for graduate level work in mathematics

MATH 353 Introductory Complex Analysis (3 Credit Hours)
Pre-requisites: (MATH 264 and MATH 266) and MATH 351
This course provides an introduction to the theory of functions of a complex variable, including analytic functions, contour integrals, the Cauchy integral formula, harmonic functions, Laurent series, residues and poles, conformal mapping, and other selected topics.
Outcomes:
Students will obtain an understanding of the fundamentals of complex analysis that will prepare them for advanced work in mathematics

MATH 355 Methods of Applied Mathematics (3 Credit Hours)
Pre-requisites: MATH 264
Vector calculus, linear transformations, matrices, series solutions of differential equations, special functions; Fourier series, Fourier and Laplace transforms; Partial differential equations and topics from complex analysis, Green's functions, integral equations, the calculus of variations.
Course equivalencies: X-PHYS301/PHYS271/MATH355
Outcomes:
Facility with mathematical methods used in sciences and engineering

MATH 356 Mathematical Modeling (3 Credit Hours)
Pre-requisites: MATH 266 Linear Algebra and Differential Equations or (MATH 264 Ordinary Differential Equations and MATH 212 Linear Algebra)
This course will teach students how to use various areas of mathematics, such as vector calculus, linear algebra, and ordinary differential equations, to formulate mathematical models in, for example, particle and continuum mechanics, biology, economics, finance, etc.
Outcomes:
Students will learn how to formulate mathematical models

MATH 358 Introduction to Optimization (3 Credit Hours)
Pre-requisites: (MATH 162 or MATH 263A) and (MATH 212 or MATH 266)
The course is an introduction to linear, nonlinear, and integer optimization, and may include optimization on graphs, stochastic optimization, etc. Modeling of real-life problems as optimization problems, mathematical analysis of resulting optimization problems, and computational approaches to solving the problems will be covered.
Course equivalencies: X-MATH358/STAT358
Outcomes:
Students will learn how to recognize optimization problems, model real-life challenges as optimization problems, perform mathematical analysis of the problems, and solve the problems using computational tools

MATH 360 Introduction to Game Theory (3 Credit Hours)
Pre-requisites: MATH 162 or MATH 162
The noncooperative and cooperative theories of games. Two person zero sum matrix games, nonzero sum N-person games, Nash equilibria of games with a continuum of strategies, auctions, duels. Cooperative game theory, including the theory of bargaining, the theory of fair allocation of rewards using the nucleolus and using the Shapley value. Students will obtain an understanding of the fundamentals of mathematical game theory.

MATH 365 Introduction to Partial Differential Equations (3 Credit Hours)
Pre-requisites: MATH 264 or MATH 266
This course provides an introduction to basic topics in partial differential equations (PDE). In addition to first order PDE, such as the transport equation, the main types of second order PDE, including the Laplace equation, the heat equation, and the wave equation, will be studied in detail.
Outcomes:
Students will learn fundamental results and methods in partial differential equations and their applications

MATH 366 Applied Dynamical Systems (3 Credit Hours)
Pre-requisites: MATH 266 Linear Algebra and Differential Equations or (MATH 264 Ordinary Differential Equations and MATH 212 Linear Algebra)
Modeling, analysis, and prediction of short-term and asymptotic behavior of dynamical systems is studied. Continuous-time and discrete-time dynamical systems are considered, and modeled by differential and difference equations, respectively. Motivation comes from biological, chemical, mechanical, and engineering systems. Students will learn how to model dynamical systems and predict their behavior.

MATH 376 Formal Language & Automata (3 Credit Hours)
Pre-requisites: COMP 163 or MATH 201 or MATH 212 or MATH 266
This course introduces formal language theory, including such topics as finite automata and regular expressions, pushdown automata and context-free grammars, Turing machines, undecidability, and the halting problem.
Course equivalencies: X-COMP376/MATH376
Outcomes:
An understanding of the theoretical underpinnings of computability and complexity in computer science

MATH 386 Introduction to Topology (3 Credit Hours)
Pre-requisites: MATH 351
This first course in topology discussed topological spaces, continuity, connectedness, path-connectedness, compactness, product spaces, quotient spaces, Tychonoff's theorem, the Baire category theorem, and other selected topics.
Outcomes:
Students will obtain a background in topology that will allow them to apply this topic to other areas of mathematics or to pursue graduate studies

MATH 388 Special Topics in Mathematics (1-3 Credit Hours)
This course covers advanced topics in mathematics, including analysis, topology, algebra, applied mathematics, and logic.
Outcomes:
Students will obtain an understanding of an advanced topic in their major

MATH 390 Undergraduate Seminar (1 Credit Hour)
Pre-requisites: Senior Standing, including completion of MATH 304/STAT 304 or MATH 313 or MATH 351
The seminar will cultivate students' presentation skills through participation in and critical discussion of brief lectures on familiar and unfamiliar topics; preparation and presentation of two brief lectures by the student (one on a familiar topic from the curriculum, one on a higher level material not customarily from the curriculum); and preparation of an extended abstract summarizing the advanced material presented.
Outcomes:
Students will gain the ability to present material in Mathematics and applications to a general audience

MATH 395 Capstone Seminar (3 Credit Hours)
Pre-requisites: MATH 313 Abstract Algebra, MATH 351 Introduction to Real Analysis I, and MATH 390 Undergraduate Seminar
The course unifies the knowledge gained in previous Mathematics courses and provides an opportunity for in-depth study and presentation of advanced material not usually covered in the standard Mathematics curriculum.
Outcomes:
Students will learn how to integrate previous knowledge in exploring new topics in Mathematics, discover applications to other disciplines, and refine their mathematical writing and presentation skills

MATH 398 Independent Study (1-6 Credit Hours)
This course allows students to engage in independent study on selected topics in mathematics under the supervision of a faculty member.
Outcomes:
Students will obtain an understanding of an advanced topic in their major

MATH 401 Introduction to Graduate Study in Mathematics (1 Credit Hour)
Pre-requisites: Graduate Student status
This is a professional development seminar for the beginning graduate student. Through short lectures, faculty panels, career panels, regular reading and writing assignments, and assorted workshops, it provides the student with the tools they need to succeed in the program, and beyond.
Outcomes:
Students will: gain practice reading, writing, listening to, and summarizing advanced mathematics; learn the pedagogical, ethical, and DEI matters associated with careers in the mathematical sciences; gain practice giving lectures, writing problem-sets, and grading mathematics; explore possible career trajectories

MATH 404 Probability & Statistics I (3 Credit Hours)
As the first part in a two-semester sequence, this course introduces basic principles of probability including combinatorial methods, probability and cumulative density and mass functions, moment generating functions and applications, expected values and variance and other moments, and order statistics. This course emphasizes related theorems and proofs.
Course equivalencies: X-MATH404/STAT404

MATH 405 Probability & Statistics II (3 Credit Hours)
As the second part in a two-semester sequence, this course thoroughly explores the central limit theorem and its variants and uses, estimation, hypothesis testing, sufficiency, efficiency, uniformly most powerful methods, information, and asymptotic methods. Time permitting, Bayesian topics may also be explored and discussed.
Course equivalencies: X-MATH405/STAT405

MATH 406 Stochastic Processes (3 Credit Hours)
This course addresses topics such as finite-state Markov processes and Markov chains, classification of states, long-run behavior, continuous time processes, birth and death processes, random walks, and Brownian motion.
Course equivalencies: X-MATH406/STAT406

MATH 409 Advanced Numerical Analysis (3 Credit Hours)
Introduction to computational methods and error analysis. Topics include numerical solution of equations, interpolation and approximation, numerical differentiation and integration, numerical solution of ordinary and partial differential equations. Numerical methods in linear algebra, such as approximate solutions to the eigenvalue problem, will also be covered.
Course equivalencies: X-COMP409/MATH409

MATH 413 Algebra I (3 Credit Hours)
As the first part in a two-semester sequence, this course covers basic algebraic structures, focused mainly on groups. Topics include normal subgroups, isomorphism theorems, actions on sets, and Sylow theorems. Additional topics chosen from linear groups, category theory, homological algebra, and representation theory.

MATH 414 Algebra II (3 Credit Hours)
As the second part in a two-semester sequence, this course covers basic algebraic structures, focused mainly on rings and fields. Topics include integral domains, vector spaces, modules, etc., Additional topics chosen from Galois theory, Dedekind domains, category theory, tensor products, homological algebra, and representation theory.

MATH 415 Topics in Linear Algebra (3 Credit Hours)
An abstract approach to the study of finite- and infinite-dimensional vector spaces and their transformations. Selected topics may include similarity, duality, canonical forms, singular value decomposition, inner products, discrete Fourier transform, bilinear forms, Hermitian and unitary spaces.

MATH 416 Survey of Algebra (3 Credit Hours)
Pre-requisites: Graduate Student status
A survey course in three parts. I: the theorems of Burnside, Sylow, and Jordan-Holder, toward the classification of finite simple groups. II: (noncommutative) rings and modules over PIDs, including applications to classification problems. III: additional topic chosen by instructor, e.g., category theory, homological algebra, division rings, and representation theory.
Outcomes:
Students will demonstrate facility with standard proof techniques in abstract algebra, and the ability to work with algebraic structures (including actions, morphisms, and quotients; concretely and abstractly); Students will recognize the common theme of classification uniting the course topics

MATH 418 Combinatorial Mathematics (3 Credit Hours)
An introduction to the basic methods of counting and generation, including: induction, pigeon-hole principle, permutations, combinations, recurrence relations, generating functions, and inclusion-exclusion principle. Topics drawn from partitions, graph theory, graph coloring, and combinatorial design, Polya's theory, Ramsey's theorem, and optimization problems.
Course equivalencies: X-COMP418/MATH418

MATH 420 Topics in Mathematical Logic (3 Credit Hours)
Pre-requisites: MATH 313 or MATH 351 or permission of the instructor
This course will be a mathematical study of the concepts of truth and proof and how they relate to each other. The main topics to be covered are propositional logic, first order predicate logic, computability and undecidability results.
Outcomes:
Students will develop proof writing skills, expand mathematical literacy, understand the expressive power and limitations of propositional and predicate logics and learn the mathematical meaning of "truth" and "proof"

MATH 422 Advanced Topics in Number Theory (3 Credit Hours)
Pre-requisites: MATH 201 or the equivalent or permission of the instructor
Topics chosen from: Pythagorean triples, Fermat's Last Theorem, Pell's equation, Fermat descent, primes in arithmetic progressions, Mersenne primes, perfect numbers, primitive roots, primality testing, Carmichael numbers, RSA encryption, quadratic residues, quadratic reciprocity, integers as the sum of squares, Gaussian integers, continued fractions, the distribution of primes, Diophantine approximation, elliptic curves; others.
Outcomes:
Understand the importance of historically significant concepts and problems in number theory; Understand the proofs of related theorems; Solve problems and prove theorems from topics covered in class

MATH 428 Algebraic Coding Theory (3 Credit Hours)
Codes with algebraic structure for error control are examined. Block codes including Hamming codes and Reed-Muller codes, BCH codes, quadratic residue codes, and other cyclic codes and their implementation are treated. Other topics may include: convolutional codes, efficiency considerations, and Shannon's fundamental theorem of information theory.
Course equivalencies: X-COMP428/MATH428

MATH 431 Cryptography (3 Credit Hours)
This course introduces the formal foundations of cryptography and also investigates some well-known standards and protocols, including private and public key cryptosystems, hashing, digital signatures, RSA, DSS, PGP, and related topics. Additional topics may include more modern cryptosystems, such as those based on elliptic curve and lattices.
Course equivalencies: X-COMP431/MATH431

MATH 443 Intro to Algebraic Topology (3 Credit Hours)
In the study of topology, algebraic constructions (called "invariants") are used to help determine whether two differently presented topological spaces are indeed different. In this course, we introduce various topics related to this endeavor, including homotopy equivalence of topological spaces, group presentations, homomorphisms of spaces and of groups, covering spaces, the fundamental group, and homology theories. Time permitting, the cohomology ring of a space will also be introduced.

MATH 444 Topics in Geometry (1-3 Credit Hours)
An axiomatic approach to the study of geometry. While Euclidean geometry will be the main focus, elliptic and hyperbolic geometries will also be studied in detail. Additional non-Euclidean geometries (including projective, metric, and finite) and additional approaches (such as transformations and synthetic treatments) will also make an appearance.

MATH 445 Financial Math Derivatives (3 Credit Hours)
A first course in the mathematics of derivatives pricing. Topics include options markets, Black-Scholes pricing formulas, stochastic calculus, hedging schemes, binomial option pricing, exotic options, and more general derivatives.

MATH 451 Analysis I (3 Credit Hours)
A first course in the foundations of analysis. Topics include measure theory, Lebesgue integration, Hilbert and Banach spaces, and complex analysis.

MATH 452 Analysis II (3 Credit Hours)
A second course in the foundations of analysis. Topics include the Fubini Theorem, differentiation, and linear and nonlinear functional analysis.

MATH 453 Complex Analysis (3 Credit Hours)
Pre-requisites: Graduate Student Status
An introduction to functions of a single complex variable. Topics include analytic functions, contour integrals, Cauchy integral formula, harmonic functions, Liouville's theorem, Laurent series, analytic continuation, and conformal mapping. Additional topics may include theorems of Picard and Rouché, the Riemann mapping theorem, Riemann surfaces, and the fast Fourier transform.
Outcomes:
Students will be able to: analyze limits and continuity for complex functions; evaluate contour integrals (by the fundamental theorem, by Cauchy integral formula, and by the residue theorem); and represent functions as Laurent series, classifying singularities and poles

MATH 454 Survey of Analysis (3 Credit Hours)
Pre-requisites: Graduate Student status
An introduction to advanced topics in analysis, including measure theory, functional analysis and partial differentials equations. Measurable sets; the Lebesgue integral in Rn; Lp and other function spaces; weak convergence; Lax-Milgram Theorem; and the calculus of variations. These topics are then applied to the study of linear PDEs. Students will be able to apply these concepts to study PDEs.
Outcomes:
Students will understand the central elements of Lebesgue integration (from measurable sets to the fundamental theorem of calculus for Lebesgue integrals) and of Lp spaces (including Minkowski and Hölder inequalities)

MATH 456 Introduction to Mathematical Modeling (3 Credit Hours)
A course in modelling. Mathematics has the power to describe the world and predict future events. This can be seen through its use in physics, economics, and biology. In this course students will learn how to harness the power of mathematics to model real world phenomenon. This will mainly be done using calculus and differential equations, but other mathematical tools will be used as well.

MATH 458 Topics in Optimization (3 Credit Hours)
This course presents the study of selected mathematical models and their application to applied problems. Topics in linear and mathematical programming, optimization theory, and game theory are examined.
Course equivalencies: X-MATH458/STAT458/428

MATH 460 Theory of Games (3 Credit Hours)
The noncooperative and cooperative theories of games. Two person zero sum matrix games, nonzero sum N-person games, Nash equilibria of games with a continuum of strategies, auctions, duels. Cooperative game theory, including the theory of bargaining, the theory of fair allocation of rewards using the nucleolus and using the Shapley value.

MATH 464L History of Math with Science Contributions for Middle Grades (3 Credit Hours)
This course will provide a thematic approach to the history of mathematics with emphasis on contributions by noted mathematicians, mathematical societies and scientists highlighting women and under-represented populations. The history of numbers and numerals, computation, geometry, algebra, trigonometry, calculus, and science patterns will be explored emphasizing the contributions of the Babylonian, Egyptian, Chinese, and Roman civilizations as well as such individuals as Euclid, Fermat, Archimedes, Kepler, Pythagoras, Euler, Hypatia, Sonja Kovalevsky, Emmy Noether and others as appropriate. The influence of technology and its applications will also be presented as appropriate.
Outcomes:
Students will obtain a unique historical perspective on the various areas of mathematics in the middle grades

MATH 465 Introduction to Partial Differential Equations (3 Credit Hours)
This course is an introduction to the subject of partial differential equations. Focus will be on studying linear partial differential equations, such as the wave equation, that appear ubiquitously in nature. To solve these equations we will use techniques such as separation of variables and Fourier series. We will also discuss different boundary conditions, and their physical interpretation.
Course equivalencies: X-MATH465/STAT465

MATH 466L Geometry with Science Applications for the Middle Grades (3 Credit Hours)
Pre-requisites: This course is limited to graduate education students only; it is not accepted for other Mathematics and Statistics graduate degree programs
No course description is available

MATH 468L Probability and Statistics with Science Applications for Middle Grades (3 Credit Hours)
Pre-requisites: School of Education Graduate Program
Data collection and display, simulations, surveys, probability and elementary statistics such as mean, median, mode, standard deviation, etc. will be the focus of this course (Illinois Learning Standard Goal 10) Appropriate techniques for graphing (scatter plots, histograms, regression, correlation) with and without technology will be a focus of this course.
Outcomes:
Students will obtain a background in the fundamentals of descriptive and inferential statistics

MATH 469L Mathematics and Science Applications for Middle Grades (3 Credit Hours)
Mathematical concepts such as rates, ratios and proportions, probability and statistics and measurement that support scientific investigation and analysis will provide the focus for this course. Hands-on activities that illustrate the connections be used. Hands-on activities that illustrate the connections between Science and Math and appropriate use of technology will be emphasized.
Outcomes:
Students will acquire knowledge of mathematics that supports scientific investigation for the middle grades

MATH 475 Functional Analysis (3 Credit Hours)
Metric, normed, Banach, Hilbert, and sequence spaces. Linear operators and Fourier analysis. Hahn-Banach extension principle, Baire category, and uniform boundedness. Selected applications to economics, physics, engineering, and quantum theory.

MATH 476 Automata & Formal Languages (3 Credit Hours)
Pre-requisites: MATH 201 or MATH 212 or COMP 163
No course description is available
Course equivalencies: X-COMP476/MATH476

MATH 486 General Topology (3 Credit Hours)
General theory of topological and metric spaces, compact spaces, convergence and completeness in metric spaces, connected spaces.

MATH 488 Special Topics in Mathematics (1-4 Credit Hours)
Selected topics in mathematics not covered in the department's regular course offerings. May be repeated for credit.

MATH 495 Graduate Practicum in Mathematics (2 Credit Hours)
Pre-requisites: MATH 401 and (MATH 414 or MATH 452 or MATH 416 or MATH 454); Graduate Student status
A project-based course. Under faculty consultation, students will design and independently carry out a research project devoted to the development, pedagogy, or application of mathematics. To earn credit for this course, the student will deliver both an oral presentation and technical paper at the level expected in the professional workplace.
Outcomes:
Students will have: analyzed professional literature from multiple sources, resulting in a motivating question for the project; gained practice communicating clearly, concisely, and in-step with discipline norms; and contributed to the learning, teaching, or application of mathematics through their findings

MATH 498 Independent Study (1-6 Credit Hours)
This is a directed study course undertaken by advanced students and supervised by a member of the graduate faculty.

MATH 595 Thesis Supervision (6 Credit Hours)
Research under faculty guidance including training in scientific writing and the production of a thesis and research presentation.

MATH 605 Master's Study (0 Credit Hours)
This course is a non-credit means of permitting students to be formally enrolled at Loyola while preparing for the final practicum.