Course Information (Description, Objectives, and Topics) from the Syllabus of Record (SOR)

updated 12-11-19

MTH 097 Course Title: Elementary Algebra

Description: Introduction to topics covered in MTH 110. A symbolic, numeric, and graphic approach to elementary algebra. Topics include linear equations and inequalities, properties of exponents, factoring, quadratic equations, and radicals. Designed for students who need additional preparation for MTH 110. Does not count toward graduation.

Objectives: After successful completion of the course, students will be able to…

1. Find solutions to linear equations and inequalities.
2. Solve quadratic equations and equations involving radicals.
3. Use the properties of exponents to simplify expressions involving exponents.
4. Use the techniques of elementary algebra to solve applied problems.
5. Communicate the solutions of their problems in writing.

Topics

1. The real number system (1 to 2 week)
2. Linear equations and inequalities (2 to 3 weeks)
3. Graphing linear equations (2 to 3 weeks)
4. Systems of linear equations in 2 variables (1 to 2 week)
5. Polynomials and properties of exponents (1 to 2 weeks)
6. Factoring polynomials (2 to 3 weeks)
7. Quadratic equations (2 to 3 weeks)
8. Expressions involving square roots (1 to 2 week)

MTH 110 Course Title: Algebra

Description: A symbolic, numeric, and graphic approach to intermediate algebra with an emphasis on applications. Topics include operations, equations, and inequalities of linear, exponential, logarithmic, quadratic, rational, and radical functions. Please see the mathematics program for placement test details.

Objectives: After successful completion of the course, students will be able to…

1. Analyze realistic or real-world situations in a mathematical way, using linear, exponential, and quadratic models.
2. Select appropriate variables to represent the functional inputs and outputs for a mathematical model of a situation using linear, exponential, and quadratic models.
3. Form an appropriate mathematical model from a description or data, using, if necessary, appropriate technological tools for linear, exponential, and quadratic models.
4. Use their linear, exponential, or quadratic model and visualization tool to create new data or make predictions about a situation
5. Evaluate if their new data prediction makes sense in the context of the problem using linear, exponential, and quadratic models.
6. Form at least one meaningful and contextually relevant sentence to describe their new data or predictions using linear, exponential, and quadratic models.

Topics

1. Lines and functions (2 to 3 weeks)
2. Systems of equations and inequalities (2 weeks)
3. Exponents, polynomials and functions (2 weeks)
4. Quadratic functions (2 to 3 weeks)
5. Exponential functions (2 to 3 weeks)
6. Inverses, radical and logarithmic functions (2 to 3 weeks)

MTH 122 Course Title: College Algebra

Description: A culminating experience in algebra for conceptual understanding and application in other fields. Primary topics include families of functions (polynomial, rational, exponential, logarithmic and their compositions), algebraic skills for making and using mathematical models, and multiple representations of algebraic relationships.

General Education: This course teaches and assesses the General Education student learning outcomes that correspond to Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Solve mathematical problems using their algebraic understanding.
2. Model real world situations and make prediction.
3. Synthesize different representations of mathematical structures.
4. Write coherent mathematical justifications.
5. Use appropriate technology to solve problems.

Topics

1. Quadratic Functions (1-2 Weeks)
2. Polynomial Functions (2-3 Weeks)
3. Rational Functions (2-3 Weeks)
4. Exponential Functions (2-3 Weeks)
5. Logarithmic Functions (2-3 Weeks)
6. Algebra of Functions (1-2 Weeks)

MTH 123 Course Title: Trigonometry

Description: A study of the trigonometric functions with an emphasis on graphing, identities, inverse trigonometric functions, and solving equations. Additional topics include solving triangles, vectors, complex numbers, and polar coordinates. Graphing calculator required: TI83 or TI84 recommended.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundations - Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1 Explain the definition of the circular functions.
2 Compute the circular functions exactly for common functions.
3 Graph sinusoidal functions and determine their equations.
4. Explain the definition of the inverse trigonometric functions.

5. Perform computations of inverse trigonometric functions.
6. Apply trigonometric identities to computations of trigonometric functions.
7. Solve equations involving trigonometric functions.
8. Solve application problems using trigonometric functions.

Topics

1. Circular functions. 2-4 weeks
2. Graphing sinusoidal functions. 2-3 weeks
3. Inverse trigonometric functions. 1-2 week
4. Recognizing and applying trigonometric identities. 2-3 weeks
5. Solving equations involving trigonometric functions. 2-3 weeks

Discretionary Topics:

Solving triangles

Vectors

Complex numbers

Polar Coordinates

MTH 124 Course Title: Precalculus: Functions and Models

Description: Study of preparatory material for calculus using symbolic algebra and trigonometry for solving equations, representing functions, and modeling, plus appropriate technology. Core topics: concept of function, average rate of change of a function, inverse and composite functions, trigonometric functions, exponential and logarithmic functions, and right triangle trigonometry.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundations - Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course the student should be able to

1. Develop broad algebraic and trigonometric skills for manipulating expressions, solving equations, and understanding and representing functions, along with graphical and numerical perspectives that support analytical work.
2. Identify the average rate of change of a function and be able to compute and interpret it, with units, in a wide range of settings.
3. Develop communication and problem-solving skills that enable them to meaningfully investigate, discuss, and solve authentic problems using proper language, syntax, and notation, both orally and in writing.

Topics

1. Difference quotient and average rate of change (will be discussed regularly throughout the course)
2. The idea of function, studied from multiple perspectives (2-3 weeks)
3. Polynomial functions (1-2 weeks)
4. Inverse and composite functions (1-2 weeks)
5. Exponential and logarithmic functions, and the relation between them (2-3 weeks)
6. Growth rates logarithmic, polynomial/rational, exponential and their connection to modeling (1-2 weeks)
7. Trigonometric functions, developed from the unit circle (2-3 weeks)
8. Trigonometry in triangles (1-2 weeks)

MTH 125 Course Title: Survey of Calculus

Description: A study of the concepts of calculus for students majoring in business, economics, life sciences, and social sciences. Differentiation and integration of algebraic, exponential, and logarithmic functions. Emphasis on applications. Please see the mathematics program for placement details.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundations - Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Describe the fundamental concepts of calculus, including limits, differentiation, integration, and optimization, in the context of business, economics, life sciences, and social sciences.
2. Use appropriate methods to calculate derivatives and integrals of algebraic, exponential, and logarithmic functions.
3. Use the fundamental concepts of calculus to represent quantitative relationships and solve problems involving rates of change in business, economics, life sciences, and social sciences.

Topics

1. Functions, Graphs, and Models (10-20%)
2. Limits of Functions (10-15%)
3. Derivatives and Differentiation (25-30%)
4. Applications of the Derivative (15-20%)
5. Integration and its Applications (25-35%)

Discretionary Topics:

Numerical Integration

Improper Integrals

Partial Derivatives and Functions of Several Variables

MTH 131 Course Title: Introduction to Mathematics

Description: A survey for non-mathematics majors. Topics selected from inductive and deductive reasoning, geometry, statistics, computers, modeling, number theory, numeration systems, the mathematics of decision-making, and applications. Fulfills Foundation - Mathematical Sciences. Please see the mathematics program for placement details.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundation – Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Describe the principles, questions, and processes that define the field of mathematics.
2. Think critically and creatively to solve multiple-step and non-routine problems that require logic and reasoning skills.
3. Use mathematical processes and principles to explore topics in pure and applied mathematics.

Topics

1. Patterns and inductive reasoning (1-2 weeks)
2. Sets and deductive reasoning (1-2 weeks)

3. Modeling and problem solving in mathematics (1-2 weeks)
4. Investigations in pure and applied mathematics (8-12 weeks)

Discretionary Topics:

Codes (e.g., bar codes, zip codes, ISBN)

Computers and algorithms

Consumer math (e.g., loans and interest)

Consumer statistics (e.g., graphs, polling, margins of error)

Counting and probability (e.g., odds in games like poker, blackjack)

Cryptography

Infinity and infinite processes (sequences, series, fractals, cardinality of sets)

Numeration systems

Topics in game theory / decision theory (e.g., zero sum, voting & election methods)

Topics in geometry (e.g., the golden ratio, geometry in nature, taxi-cab geometry)

Topics in number theory (e.g., clock arithmetic)

MTH 201 Course Title: Calculus I

Description: A development of the fundamental concepts of calculus using graphical, numerical, and analytic methods with algebraic and trigonometric functions of a single variable. Limits and continuity, derivatives, indefinite integrals, definite integrals, and the Fundamental Theorem of Calculus; applications of derivatives and integrals.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundation – Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Apply the definite integral to compute the total change of a function from the rate of change and to compute area.
2. State the Fundamental Theorem of Calculus.
3. Describe the relation between the definite integral of a function and areas between the graph of that function and the horizontal axis.
4. Understand the definition of the definite integral as the limit of a Riemann sum.
5. Compute derivatives using the product rule, quotient rule, and chain rule.
6. Conceptually understand and evaluate limits, including L'Hopital's Rule.
7. State the formal definition of the derivative of a function and the purpose of each symbol in that definition.
8. Discuss the interpretations of the derivative as the slope of a tangent line and an instantaneous rate of change of a function.
9. Determine the tangent line to a function at a specific point on the graph of the function.
10. Be fluent with the concept of function and be able to determine information about a function through the processes of differentiation and integration.

Topics

1. Limits and continuity (approx 1 week).
2. The concept of a derivative including the derivative at a point, the derivative of a function, the second derivative, interpretations of the derivative and second derivative, and linear approximations using derivatives (approx 2-3 weeks).
3. Derivatives of basic functions including polynomial functions, exponential and logarithmic functions, trigonometric and inverse trigonometric functions (approx 3-4 weeks).
4. Rules for differentiation including the product rule, the quotient rule, the chain rule, and implicit differentiation. (approx one to two weeks).
5. Use first and second derivatives to help solve optimization problems, to study families of functions, to solve related rates problems, and to use L'Hopital's rule for evaluating limits (approx 3-4 weeks).
6. The definite integral, the Fundamental Theorem of Calculus, and theorems about definite integrals (approx 2-3 weeks).

MTH 202 Course Title: Calculus II

Description: Continuation of MTH 201 using graphical, numerical, and analytic methods to study exponential, logarithmic, hyperbolic, and inverse trigonometric functions. Indeterminate forms, improper integrals, integration techniques, sequences and series, Taylor polynomials, and power series.

Objectives: After successful completion of the course, students will be able to…

1. Explain the First and Second Fundamental Theorem of Calculus, techniques and applications of integrals, Series, particularly Taylor polynomials and series, and Differential Equations.
2. Interpret the interrelationships between information given in graphical, numerical, and symbolic forms.
3. Use communication skills, both verbal and written, in mathematics.
4. Apply the concepts of integration to solve mathematical problems in geometry, physics and economics.
5. Apply quantitative and qualitative methods to differential equations to study applied problems such as population growth.
6. Determine an appropriate method to calculate a given integral.
7. Use an appropriate test to determine convergence of a given series.

Topics

1. Definite Integral and the Fundamental Theorem of Calculus, Approximation Definite Integrals (2 weeks).
2. Techniques of Integration and Improper Integrals. (3 weeks).
3. Applications of the Definite integrals (geometry, physics, economics) (2 weeks)
4. Differential Equations (2 weeks)
5. Sequences and Series (3 weeks)
6. Taylor Polynomials, Taylor Series, Power Series (2 week)

MTH 203 Course Title: Calculus III

Description: Continuation of MTH 202 using graphical, numerical, and analytic methods to study parametric equations, polar coordinates, vector algebra in two and three dimensions, differentiation and integration of vector functions of a single variable, and scalar functions of several variables.

Objectives: After successful completion of the course, students will be able to…

1. Explain the ideas of differentiation and integration of vector valued functions with a single variable; partial derivatives; and multiple integrals of scalar functions of several variables.
2. Interpret the interrelationships between information given in graphical, numerical, and symbolic forms.
3. Use communication skills, both verbal and written, in mathematics.
4. Apply the concepts of differentiation and integration appropriately both on several variable and vector valued functions to solve mathematical problems in geometry and physics.
5. Determine appropriate methods to calculate derivatives and integrals.

Topics

1. Vectors in Euclidean space, Dot Product, Cross Product, Lines and Planes (1 week).
2. Vector valued functions (Space Curves, derivatives and integrals of Vector-Valued Functions, Arc Length and Curvature (2 weeks)
3. Functions of Several Variables (Two – Three variables): Limits, First and Second order partial derivatives, Linearization, Directional derivatives. (2 weeks)
4. Optimization, Constrained Optimization: Lagrange Multipliers. (2 weeks)
5. Integrating Functions of Several Variables: Double Riemann Sums, Double integrals over rectangular region and Double integrals over general regions. (2 weeks)
6. Applications of Double integrals: Center of Mass, finding the area between curves, Probability. (2 weeks)
7. Double integrals in Polar Coordinates. (1 week)
8. Parametrized Curves and Surfaces. (1week)
9. Triple Integrals. (1 week)

MTH 204 Course Title: Linear Algebra I

Description: An introduction to systems of linear equations emphasizing conceptual understanding and computational thinking. Primary topics include solutions to linear systems, vector and matrix algebra, span and linear independence, bases, eigenvectors and eigenvalues. Applications will be integrated throughout the course.

Objectives: After successful completion of the course, students will be able to…

1) Analyze systems of linear equations and describe their solution spaces.
2) Describe how the pivot positions of an augmented matrix influence the nature of the solution space to a linear system.
3) Demonstrate algebraic and geometric fluency with vectors.
4) Interpret questions about linear systems as questions about linear combinations of vectors.
5) Describe the concept of span of a set of vectors and apply it to determine the span of a set of vectors.
6) Describe the concept of linear independence of a set of vectors and apply it to determine whether a set of vectors is linearly independent.
7) Interpret matrix transformations as functions defined through matrix multiplication and create

specific matrix transformations to perform geometric operations.

8) Calculate matrix sums, products, and multiples by scalar, and recognize matrix products as arising from composing matrix transformations.
9) Recognize a basis for R n and use the coordinate system it defines to solve problems.
10) Recognize an invertible matrix and find its inverse.
11) Apply one of several algorithms for finding the determinant of a matrix, and use the determinant to determine if a matrix is invertible.
12) State the definition and intuitive meaning of an eigenvalue-eigenvector pair of a square matrix.
13) Apply a conceptual understanding of linear systems to find the eigenvalues and eigenvectors of a square matrix.
14) Demonstrate how the theory of eigenvalues and eigenvectors is used to solve problems in dynamical systems.
15) Use computer algebra technology as a tool to solve important problems in linear algebra.

Topics

1. Linear Systems (1-2 weeks)
2. Vector and Matrix Algebra and its Connection to Linear Systems (1-2 weeks) Span and Linear Independence (1-2 weeks)
3. Matrix Transformations (1 week)
4. Invertibility of Matrices and Bases (1-1.5 weeks)
5. Determinants (1 week)
6. The Null and Column Space of a Matrix (1 week)
7. Eigenvalues and Eigenvectors: General Theory (2-3 weeks)
8. Applications to Dynamical System (2 weeks)

MTH 205 **Course Title:** Linear Algebra II

Description: A study of linear algebra centered on orthogonality and the singular value decomposition emphasizing conceptual understanding and computational thinking. Primary topics include orthogonality, the eigenvalue decomposition, the singular value decomposition, applications, and select topics in numerical linear algebra.

Objectives: After successful completion of the course, students will be able to…

1) Describe and utilize an orthogonal basis.
2) Convert any basis to an orthogonal basis.
3) Employ orthogonal projections to solve important problems, such as least squares problems.
4) Describe and compute (for small matrices) key matrix factorizations including QR, the eigenvalue decomposition, and singular value decomposition.
5) Use computational technology to compute key matrix factorizations whenever needed for use in other problems.
6) Apply the eigenvalue decomposition and/or singular value decomposition to describe the action of a linear transformation in terms of a basis of vectors that only get stretched by the transformation.
7) Apply the eigenvalue decomposition and/or singular value decomposition to solve important real world problems.

8) Apply the theory and applications of Markov chains and leverage the roles that eigenvalues and eigenvectors play.
9) Use iterative algorithms to solve important problems numerically, such as solving large systems of equations or finding the eigenvalues and eigenvectors of a matrix.

Topics

1. Orthogonality (3 weeks)
    a. Inner product, orthogonal sets, orthogonal bases
    b. Orthogonal matrices
    c. Orthogonal projections
    d. The Orthogonal Decomposition Theorem
    e. Gram-Schmidt
    f. QR Factorization
    g. Least squares problems
2. The Singular Value Decomposition & its Applications (7-8 weeks) Applications selected from parts d-j below.
    a. The Eigenvalue Decomposition (EVD) of a Real Symmetric Matrix (EVD)
    b. The geometry of the EVD
    c. The SVD as an analog of the EVD (geometrically, then algebraically)
    d. The SVD and Least Squares Problems
    e. Principal component analysis
    f. The SVD and image processing/compression: outer products and low rank approximations
    g. The SVD and adjacency matrices: singular vectors subtle secrets
    h. The SVD and removing noise from data
    i. The SVD and facial recognition
    j. The SVD and surveillance video
3. The eigenproblem revisited (2-3 weeks): Iteration
    a. Stochastic matrices and the power method
    b. Markov chains and related applications (Google Page Rank revisited)
    c. The QR algorithm
    d. Using the SVD to compute eigenvalues
4. Optional topics in numerical linear algebra (1-2 weeks, time permitting)
    a. Iterative solutions to systems of equations
    b. Givens Rotations and Householder Reflections
    c. Cholesky Factorization, LU Factorization

MTH 210 Course Title: Communicating in Mathematics

Description: A study of proof techniques used in mathematics. Intensive practice in reading mathematics, expository writing in mathematics, and constructing and writing mathematical proofs. Mathematical content includes elementary logic, congruence arithmetic, set theory, functions, equivalence relations, and equivalence classes.

Objectives: After successful completion of the course, students will be able to…

1. Explain standard methods of mathematical proof (including direct proofs, logical equivalencies, proof by contradiction, mathematical induction, case analysis, and counterexamples).
2. Create mathematical proofs using standard methods of mathematical proof.
3. Solve and generalize mathematical problems.
4. Critique mathematical proofs.
5. Determine appropriate method of proof for a given conjecture or argument

Topics

1. Logic (1 to 2 weeks): Statements and logical operators; conditional statements; logically equivalent statements; predicates, sets, and quantifiers; negations of quantified statements.
2. Elementary Number Theory (2 to 4 weeks): Properties of Integers, Rational and Irrational Numbers; the Division Algorithm; congruence and congruence arithmetic.
3. Methods of Proof (2 to 3 weeks): Direct proof; Proof using the contrapositive and other logical equivalencies; Proof by contradiction; Proof using cases; Choose an element method; Mathematical Induction.
4. Elementary Set Theory (2 to 3 weeks): Set notation and operations; Set and Set Operations Properties.
5. Functions (2 to 4 weeks): Definition and function notation, operations and properties.
6. Equivalence Relations (1 to 3 weeks): Relations and properties of relations; equivalence relations and classes.

MTH 221 Course Title: Mathematics for Elementary Teachers I

Description: Exploration of the teaching and learning of geometry, measurement, patterns and functions, probability, and statistics in elementary school mathematics, emphasizing development of mathematical representations and communication. Concepts are developed through hands-on experiences exploring mathematical models, strategies, relationships, and problem-solving.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Foundation – Mathematical Sciences as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate understanding of mathematical concepts, skills, and connections in the areas of geometry, measurement, patterns and functions, probability, and statistics.
2. Demonstrate a beginning understanding of what it means to learn and teach for mathematical understanding in the elementary school, with a special emphasis on the selection and use of appropriate instructional resources, knowledge and use of appropriate teaching methodology, and knowledge of ways that elementary school children think about mathematics with respect to geometry, measurement, patterns and functions, probability, and statistics.
3. Use the mathematical processes of communication, connections, problem solving, representation, and reasoning and proof as they solve problems and provide clear explanations and sound reasoning to the results of mathematical explorations.

4. Demonstrate a beginning understanding of goals and objectives of mathematics in the elementary school, with a special emphasis on those related to the teaching and learning of geometry, measurement, patterns and functions, probability, and statistics.
5. Demonstrate a beginning understanding of cultural and historical developments in relation to the teaching and learning of geometry, measurement, patterns and functions, probability, and statistics.

Topics

1. Mathematics Pedagogy (integrated throughout the course in the exploration of each topic)
2. Mathematical Processes (integrated throughout the course in the exploration of each topic)
3. Geometry (Approximately 5-6 weeks or 30 to 40% of the course content)
4. Measurement (Approximately 3-4 weeks or 20 to 30% of the course content)
5. Patterns and Functions (Approximately 1-2 weeks or 10 to 15% of the course content & integrated throughout the course in the exploration of each topic)
6. Probability (Approximately 1-2 weeks or 10 to 15% of the course content)
7. Statistics (Approximately 2-3 weeks or 15 to 20% of the course content)

MTH 222 Course Title: Mathematics for Elementary Teachers II

Description: Exploration of the teaching and learning of number and operations (whole numbers, fractions, decimals, and number theory) in elementary school mathematics, emphasizing the development of number sense and unitizing. Concepts are explored through models, strategies, relationships, algorithms, and problem solving. Fieldwork includes evaluating and tutoring elementary children.

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate understanding of mathematical concepts, skills, and connections in the areas of whole number arithmetic, rational numbers (fractions and decimals), and number theory (particularly multiplicative structures).
2. Apply pedagogical content knowledge focused on what it means to learn and teach for mathematical understanding to select instructional resources and make pedagogical decisions related to the teaching and learning of numbers and their operations.
3. Analyze how elementary school children think about mathematics, especially on topics in the area of numbers and their operations.
4. Communicate with children about mathematics, evaluate children's understanding of specific mathematics, and provide appropriate instruction based on that evaluation.
5. Summarize current national and state recommendations for the goals and objectives of mathematics in the elementary school, particularly those related to the teaching and learning of numbers and their operations.

Topics

1. Mathematics Pedagogy (integrated throughout the course in the exploration of each topic)
2. Mathematical Processes (integrated throughout the course in the exploration of each topic)
3. Whole Numbers (approximately 8-10 weeks)
4. Number Theory (integrated throughout the course in the exploration of each topic)
5. Rational Numbers (Fractions & Decimals) (approximately 4-6 weeks)
6. Tutoring Field Experience Component (approximately 2-4 weeks)

MTH 223 Course Title: Mathematics for Elementary Teachers III

Description: Explores teaching and learning of number and operations, geometry, measurement, patterns and functions, probability and statistics in elementary school mathematics, emphasizing development of number sense, unitizing, mathematical representations, and communication. Exploration through models, strategies, relationships, algorithms, and problem solving. Fieldwork: evaluating and tutoring children. Equivalent: MTH 221 and MTH 222.

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate understanding of mathematical concepts, skills, and connections in the areas of whole number arithmetic, rational numbers (fractions and decimals), and number theory (particularly multiplicative structures), geometry, measurement, patterns and functions, probability, and statistics.
2. Use the mathematical processes of communication, connections, problem solving, representation, and reasoning and proof to do mathematics.
3. Apply pedagogical content knowledge focused on what it means to learn and teach for mathematical understanding to select instructional resources and make pedagogical decisions related to the teaching and learning of numbers and their operations, geometry, measurement, patterns and functions, probability, and statistics.
4. Analyze how elementary school children think about mathematics, especially on topics in the area of numbers and their operations, geometry, measurement, patterns and functions, probability, and statistics.
5. Communicate with children about mathematics, evaluate children's understanding of specific mathematics, and provide appropriate instruction based on that evaluation.
6. Summarize current national and state recommendations for the goals and objectives of mathematics in the elementary school, particularly those related to the teaching and learning of numbers and their operations, geometry, measurement, patterns and functions, probability, and statistics.

Topics

1. Mathematics Pedagogy (integrated throughout the course in the exploration of each topic)
2. Mathematical Processes (integrated throughout the course in the exploration of each topic)
3. Patterns and Functions (integrated throughout the course in the exploration of each topic)
4. Whole Numbers (approximately 4 weeks)
5. Number Theory (integrated throughout the course in the exploration of each topic)
6. Rational Numbers (Fractions & Decimals) (approximately 2 weeks)
7. Geometry (approximately 2 weeks)
8. Measurement (approx. 1 week and integrated into other topic areas)
9. Probability (approx. 1 week and integrated into other topic areas)
10. Statistics (approx. 2 weeks and integrated into other topic areas)
11. Tutoring Field Experiences (approximately 2 weeks, some of which may occur outside of class time)

MTH 225 Course Title: Discrete Structures: Computer Science

Description: Logic, sets, counting techniques, cardinality, relations, functions and sequences, matrices, mathematical induction, and computer science applications.

Objectives: After successful completion of the course, students will be able to…

1. Compute basic numerical and symbolic expressions involving numbers in different bases, modular arithmetic, sets, functions, and symbolic logic.
2. Solve complex counting problems using computational thinking and the tools of combinatorics.
3. Formulate computational problems in terms of sets, functions, logic, and combinatorics.
4. Write clear, correct, and convincing arguments to explain the correctness of a solution using combinatorial proof and mathematical induction.
5. Apply effective problem-solving skills in solving computational problems.
6. Explain methods and solutions of computational problems in a clear way to a specified target audience.
7. Demonstrate fluency in applying computer programming in the formulation and solutions of mathematical problems.
8. Assess one's own work in mathematical problem solving and apply feedback to make improvements to one's own work.

Topics

1. **Arithmetic**: Representation and arithmetic with integers in base 2, 8, 10, and 16; binary arithmetic; the modulo operator and modular arithmetic (1-2 weeks)
2. **Logic**: Propositions, conditional statements; conjunctions, disjunctions and negations; truth tables; logical equivalence; predicates and quantification (2-3 weeks)
3. **Sets and Functions**: Set notation; subset and element relations; union, intersection, and complement; Venn diagrams; cardinality and power sets; Cartesian products; functions and non-functions; injective, surjective, and bijective functions; special functions for CS (floor, ceiling, etc.) (2-3 weeks)
4. **Combinatorics**: Additive and multiplicative principles; binomial coefficients (intro to recurrence relations and recursion); combinations and permutations; principle of inclusion and exclusion; combinatorial proofs (3-4 weeks)
5. **Sequences and Recursion**: Closed-formula and recursive definitions of sequences; arithmetic and geometric sequences; polynomial fitting; solving recurrence relations; proofs using (weak) mathematical induction. (3-4 weeks, with proof by induction occupying 1-2 of those weeks)

Discretionary Topics:

Instruction in a computer language, for example Python.

MTH 229 Course Title: Mathematical Activities for Secondary Teachers

Description: In-depth study of mathematical content suitable to secondary classrooms. Integrated discussions of student's learning, pedagogy, secondary curricula, NCTM Standards, and relevant research. Service learning includes 20 hours of active classroom observations, including lesson design and implementation. Within the mathematics major or minor, applies only to secondary certification emphasis.

Objectives: After successful completion of the course, students will be able to…

1. Identify state and national mathematics content standards in a lesson.
2. Evaluate curricular materials for quality and content.
3. Solve mathematical problems in multiple manners and find connections from teacher content knowledge.
4. Plan cohesive lesson sequence for high school mathematics.
5. Reflect and analyze an observed secondary classroom.

Topics

1. Quadratic Functions (2-3 weeks) representation, behavior, application, solution, simplification.
2. Polynomials of Degree Greater Than 2 (1-2 weeks) representation, behavior, application, solution, simplification.
3. Rational Functions (1-2 weeks) representation, behavior, application, solution, simplification.
4. Other families of functions (2-3 weeks) radical, logistic, normal.
5. Secondary Statistics (2-3 weeks) measures of central tendency, variance, statistical displays, regression.
6. Secondary Geometry (2-3 weeks) definition, proof, quadrilaterals, Van Hiele levels of geometric understanding.
7. Pedagogy (throughout) lesson structure, lesson planning, state and national standards, activity types, formative and summative assessment, high leverage learning practices, cooperative learning.

MTH 300 Course Title: Vector Analysis

Description: Multivariable calculus and vector analysis including the change of variables formula, line integrals, surface integrals, Green's theorem, Stokes' theorem, and the divergence theorem. Applications in physics.

Objectives: After successful completion of the course, students will be able to…

1 Develop working knowledge of the mathematical concepts necessary for applications in physics.
2. Evaluate line integrals of vector fields directly using a parameterization of the curve.
3. Apply the Fundamental Theorem of Line Integrals to evaluate line integrals.
4. Compute physical quantities, such as work, using line integrals.
5. Evaluate surface integrals of vector fields using a parameterization of the surface.
6. Apply Stokes' Theorem or the divergence theorem to evaluate surface integrals.
7. Compute physical quantities, such as flux, using surface integrals.
8. Explain the geometrical idea behind curvature, torsion, TNB frame of reference.

Topics

1. Calculus of Vector-Valued Functions. (2 weeks)
2. Change of Parameter; Arc Length. (1 week)
3. Unit Tangent, Normal, and Binormal Vectors. (1 week)
4. Curvature. (1 week)
5. The normal and osculating planes: The osculating circle. (1 week)
6. Motion Along a Curve. (1 week)

7. Change of Variable in Multiple Integrals; Jacobians. (1 week)
8. Vector Fields. (1 week)
9. Line Integrals. (1 week)
10. Independence of Path; Conservative Vector Fields; scaler potential functions. (1 week)
11. Green's Theorem. (1 week)
12. The curl and divergence of a Vector Field. (1 week)
13. Surface Integrals. (1 week)

MTH 302 Course Title: Linear Algebra and Differential Equations

Description: Matrix algebra and determinants. Introduction to the theory of differential equations. Methods of solution (including Laplace transform techniques) of linear equations as well as some types of non-linear equations. Applications in physical, biological and social sciences.

Objectives: After successful completion of the course, students will be able to…

1. Explain the geometric and physical significance of the concepts of linear algebra.
2. Apply linear algebra and differential equations to mathematical modeling.
3. Apply computational and analytical techniques to formulate, solve, and interpret mathematical models.
4. Apply quantitative methods to ordinary differential equations.
5. Use computer algebra systems such as Maple®, Matlab®, and/or Mathematica®.
6. Explain how concepts in linear algebra and differential equations can be generalized to different contexts.
7. (Discretionary) Code pseudo-algorithms in in a modern software language such as C/C++, Java, Lua, Python, etc.

Topics

1. An overview of the subject of Differential Equations: 1 week
2. First Order Ordinary Differential Equations: Linear, various nonlinear types including exact equations, stability of solutions and related geometrical arguments, adaptive and fixed numerical methods for solving IVPs; mathematical modeling: 4 weeks
3. An overview of the subject of Linear Algebra: 1 week
4. Real & Complex matrices along with algebraic operations including the inverse, determinants, etc. and their geometric significance: 1 week
5. Algebraic linear systems and associated solution algorithms: 1 week
6. Mathematical models of network flows and economic systems: 1 week
7. Linear Dependence and Independence; Wronskian; Eigenvalues/eigenvectors: 1.5 weeks
8. Higher Order Linear ODE with constant and variable coefficients: method of undetermined coefficients (Constant case), variation of parameters, Euler-Cauchy equations, geometrical arguments and numerical approximation methods. 2 weeks
9. Mathematical models in science, engineering, and industry: overlaps with parts a) and j): 1 week
10. Solving Linear ODEs by Laplace transform methods: 1.5 weeks
11. (Discretionary) Coding in a programming language.

MTH 304 Course Title: Analysis of Differential Equations

Description: Solution methods for first order and second order linear equations (including power series and numerical methods). The linear algebra of linear systems and their solutions. Qualitative analysis of linear and nonlinear systems: phase plane; existence and uniqueness; stability, and applications in physical, biological, and social sciences.

Objectives: After successful completion of the course, students will be able to…

1. Analyze first order differential equations using slope fields
2. Solve certain first order differential equations analytically.
3. Analyze autonomous systems of linear first order differential equations using directions fields and linear algebra.
4. Analyze higher-order linear differential equations (or a linear system of differential equations) with constant coefficients (both homogeneous and non-homogeneous) using linear algebra.
5. Qualitatively analyze a first order nonlinear autonomous system of differential equations.

Topics

1. First order differential equations (2-3 Weeks)
2. Systems of linear differential equations (4-5 Weeks)
3. Inhomogeneous systems of linear differential equations (4-5 Weeks)
4. Nonlinear systems of differential equations (2-3 Weeks)

MTH 305 Course Title: Mathematical Modeling

Description: Introduction to the mathematical modeling process. Students will gain experience in the construction, computational implementation, and analysis of mathematical models arising from various applications. Models will be developed in mathematical contexts including linear algebra, calculus, discrete dynamical systems, and differential equations.

Objectives: After successful completion of the course, students will be able to…

1) Construct a mathematical model based on identified physical, biological, or social principles
2) Identify and develop mathematical algorithms to obtain approximate solutions to mathematical models
3) Apply mathematical algorithms using a programming language
4) Evaluate the validity and accuracy of the model based on the computational results
5) Analyze the computational results in the context of the application

Topics

1. Modeling, representation and sensitivity- an introduction to how equations can be used to understand real life systems. (2 weeks)
2. Modeling with Calculus. (For Example: Rates of Change, Optimization, Volume, Sequences and Series). (2-3 weeks)
3. Modeling with Linear Algebra: (For Example: Systems of linear equations, discrete stochastic processes, optimization, Data Analysis). (2-3 weeks) Modeling with Differential Equations. (3-4 weeks)
4. Final project- model development, implementation and analysis in an area of interest to the student. (4 weeks)

MTH 312 Course Title: Cryptography and Privacy

Description: An introduction to cryptography and information security with a focus on applications and issues from diverse areas. Topics will include a study of cryptographic primitives, historical cipher systems, symmetric and public-key cryptography, hash functions, digital signatures, electronic voting, and contemporary issues in privacy and security. Part of Information, Innovation, and Technology Issue.

General Education: This course teaches and assesses the General Education student learning objectives that correspond to the Information, Innovation, and Technology Issue as outlined in the General Education handbook.

Objectives: After successful completion of the course, students will be able to…

1. Explain ways in which codemaking and codebreaking have shaped, and have been shaped by, history, technology and culture.
2. Make and break cryptographic codes by hand.
3. Make and break cryptographic codes by computer.
4. Apply concepts of cryptography to current problems and issues in society.
5. Critique and defend positions on cryptographic issues in the debate between security and privacy.

Topics

1. Number theory: modular arithmetic (1-3 weeks): modular arithmetic, divisibility, primality, quotient and remainder, primitive roots.
2. Number theory: algorithms and theorems (1-3 weeks): Euclidean algorithm, XOR, conversion among number bases, Euler Function, Euler Theorem, Fermat's Little Theorem.
3. History of cryptography (throughout): Egypt, Greece, Rome, Persia, China, inventors, famous examples and uses, Enigma, connections with computing history.
4. Issues of cryptography (throughout): privacy, security, war, espionage, commercial, international, internet
5. Ciphers (throughout): substitution, shift, affine, transposition, Vigenere, one time pad, XOR, S-DES, Gamal, Diffie-Helman, RSA

MTH 315 Course Title: Discrete Mathematics

Description: Basic and advanced counting techniques, including the Pigeonhole Principle and inclusion-exclusion; recurrence relations; partial orderings; graph theory, special paths, planarity, chromatic number, networks, trees, traversals, digraphs. Algorithms and proof techniques.

Objectives: After successful completion of the course, students will be able to…

1. Apply standards for mathematical practice successfully in mathematical work.
2. Demonstrate proper written communication of discrete mathematics concepts and methods.
3. Apply discrete mathematics techniques to solve real-life problems.
4. Identify discrete structures correctly.
5. Model discrete real-life problems using enumerative and graph theory concepts.
6. Construct logically valid proofs of mathematical statements.

Topics

1. Counting techniques including the Inclusion-Exclusion Principle, and Pigeonhole Principle (2 weeks)
2. Permutations and combinations (2 weeks)
3. Recurrence relations (1 week)
4. Relations and partial orderings (2 weeks)
5. Introduction to graph theory (1 week)
6. Connectivity, Euler circuits and Hamiltonian paths (2 weeks)
7. Planarity, chromatic number (1 week)
8. Trees, networks, digraphs (2 weeks)
9. Traversals, minimal spanning trees (1 week)

MTH 322 Course Title: Geometry for Elementary Teachers

Description: Analyze characteristics and properties of geometric objects, transformations and representations, visualization and spatial reasoning, measurement systems and tools, dynamic geometric software. Integrated discussion of children's learning, curricula, standards, and research for K-8. Fieldwork includes lesson design and implementation. Within the mathematics major or minor, applies only to elementary certification emphasis. (

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate knowledge of the current national and state recommendations for the goals and objectives of teaching geometry and measurement in the elementary and middle grades.
2. Demonstrate comprehension of mathematical concepts, skills, and connections in the areas of, geometry, and measurement for elementary and middle grade mathematics.
3. Demonstrate an understanding of research in elementary and middle grade students' mathematical thinking and understanding in the area of geometry and measurement.
4. Apply what it means to learn and teach geometry and measurement for understanding in the elementary and middle grades.
5. Create or adapt and implement lessons for K-8 geometry and measurement

Topics

1. Research in elementary and middle grade students' mathematical thinking and learning in geometry and measurement. (1 -3 weeks)
2. Current national and state standards and their implications for teaching geometry and measurement elementary and middle grade mathematics. (1 – 3 weeks)
3. Methodological considerations and issues in teaching geometry and measurement with technology, in particular interactive geometric software. (1 – 3 weeks)
4. Curriculum and problem solving with 2-dimensional shapes. (1 – 3 weeks)
5. Curriculum and problem solving with 3-dimensional shapes. (1 – 3 weeks)
6. Curriculum and problem solving with transformational geometry, this includes isometries and similarity transformations. (1 – 3 weeks)
7. Curriculum and problem solving in measurement. (1 – 3 weeks)

MTH 323 Course Title: Probability and Statistics for Elementary Teachers

Description: Analyze data and chance. Gathering, organizing, constructing, and interpreting data displays, distributions and models, making inferences and predictions. Integrated discussions of children's learning, pedagogy, curricula, assessment, standards, and relevant research for K-8. Fieldwork includes designing/teaching units. Within the mathematics major or minor applies only to elementary certification emphasis.

Objectives: After successful completion of the course, students will be able to…

1. Explain the fundamental ideas of statistical reasoning and probability, including variability and chance processes.
2. Demonstrate the ability to solve probability problems.
3. Formulate statistical questions and design and implement a plan to collect appropriate data.
4. Choose and create appropriate statistical displays for specific data collections.
5. Analyze data using graphical and numerical means and interpret the results to answer a corresponding statistical question.
6. Create and teach lessons to develop statistical reasoning and understanding of probability.
7. Plan, evaluate, and implement assessments to evaluate students' statistical reasoning and understanding of probability.
8. Analyze lessons and assessments in terms of state & national guidelines in statistics & probability.

Topics

1. Assessing student understanding, formative assessment, rubrics (1-2 wks & integrated throughout)
2. Resources for teaching and assessing statistics (e.g., GAISE framework; integrated throughout)
3. The nature of variability and chance processes (1-2 wks)
4. Interpreting measures of central tendency and variability (esp. mean, median, MAD, IQR; 2-4 wks)
5. Collecting, analyzing, representing, and comparing categorical and numerical data (e.g., dot plots, box plots, scatterplots, two-way tables; 4-6 wks & integrated throughout)
6. Random sampling and statistical inference (e.g., using samples or simulated samples to draw inferences about a population or to compare two populations; 1-3 wks)
7. Simulating and modeling chance processes (e.g., random number generators, tree diagrams, tables; 1-3 wks & integrated throughout)
8. Theoretical and empirical probability (e.g., conditional probabilities, fair and unfair games, expected values; 1-3 wks)

MTH 324 Course Title: Algebra for Elementary Teachers

Description: Analyze characteristics and properties of number systems, patterns, proportions, functions, variables, and algebraic structures. Integrated discussions of children's learning, pedagogy, elementary and middle school curricula, NCTM Standards, and relevant research. Fieldwork includes writing lessons/problems and observing students. Within the mathematics major or minor, applies only to elementary certification emphasis.

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate understanding of mathematical concepts, skills, and connections in the areas of algebraic thinking, generalizing patterns, graphing, proportional reasoning, linear functions, inversely proportional functions, and exponential functions.
2. Use the mathematical processes of communication, connections, problem solving, representation, and reasoning and proof to do mathematics.
3. Summarize current national and state recommendations for the content and practice goals and objectives of mathematics at the middle school level, particularly those related to algebraic thinking, patterning, graphing, proportional reasoning, linear functions, inversely proportional functions, and exponential functions.
4. Apply knowledge of what it means to learn and teach for mathematical understanding at the middle school level by facilitating lessons with middle school students and reflecting on instructional decisions.
5. Elicit, evaluate, and interpret middle school students' conceptions and misconceptions of algebraic thinking.

Topics

1. Generalization of pictorial growth patterns and other patterns (3-4 weeks)
2. Qualitative Graphs and Graphing (1-3 weeks)
3. Proportional Reasoning (2-4 weeks)
4. Linear Functions, Inversely Proportional Functions, Exponential Functions (5-7 weeks)
5. Algebraic Thinking (integrated throughout the course)
6. Mathematics Pedagogy (integrated throughout the course)
7. Mathematical Processes (integrated throughout the course)

MTH 325 Course Title: Discrete Structures: Computer Science 2

Description: Properties of relations, equivalence relations, partial orderings, fundamental concepts of graphs, trees, digraphs, networks, and associated algorithms; computer science applications.

Objectives: After successful completion of the course, students will be able to…

1. Compute basic information about graphs, relations, and trees.
2. Solve theoretical and applied problems involving applications of basic concepts of graphs, relations, and trees.
3. Formulate computational problems in terms of graphs, relations, and trees.
4. Construct a logical framework for a proof using mathematical induction, direct proof, proof by contraposition, or proof by contradiction.
5. Analyze the structure and validity of a mathematical proof.
6. Employ effective problem-solving skills in solving computational problems.
7. Explain methods and solutions of computational problems in a clear way to a specified target audience.
8. Demonstrate fluency in applying algorithms in the formulation and solutions of mathematical problems.
9. Assess one's own work in mathematical problem solving and apply feedback to make improvements to one's own work.

Topics

1. **Proof**: The concept of proof, examples, and counterexamples; review of (weak) mathematical induction; strong induction; structural induction; direct proof; proof by contrapositive; indirect proof. (2-3 weeks initially with continued coverage throughout the course)
2. **Graphs**: Terminology and examples; representation of graphs in computer languages; the Handshaking Theorem; Euler and Hamilton paths and cycles; isomorphism; vertex coloring; minimal spanning trees. (3-4 weeks)
3. **Relations**: Terminology and examples; representation of relations in computer languages; properties of relations; composition of relations; transitive closure and Warshall's algorithm; equivalence relations; partial orderings. (3-4 weeks)
4. **Trees**: Terminology and examples; properties of trees; tree traversals. (1-2 weeks)

Discretionary Topics:

Instruction in a computer language, for example Python.

Specific applications of graphs, relations, and trees (scheduling problems, topological sorting, Huffman codes, etc.)

MTH 329 Course Title: Teaching Middle Grades Mathematics

Description: Emphasis on what mathematics is, how students learn mathematics, planning and instruction, assessment, and professional decision-making. Conceptual, constructivist, and cooperative activities assist middle grades teachers in helping their students learn mathematics connecting algebra, geometry, number, measurement, statistics, and probability. 20 hours of service-learning with middle grades students required.

Objectives: After successful completion of the course, students will be able to…

1. Demonstrate knowledge of the current national and state recommendations for the goals and objectives of mathematics in the middle grades.
2. Demonstrate comprehension of mathematical concepts, skills, and connections in the areas of algebra, rational numbers, geometry, measurement, probability and statistics for middle grade mathematics.
3. Apply what it means to learn and teach mathematics for understanding in the middle grades.
4. Demonstrate an understanding of research in middle grade students' mathematical thinking and understanding.

Topics

1. Research in middle grade students' mathematical thinking and learning. This is embedded throughout the course in the listed content areas below.
2. Current national and state standards and their implications for teaching middle grade mathematics. This is embedded throughout the course in the listed content areas below.
3. Proportional thinking in middle grade mathematics. This is embedded throughout the course in the listed content areas below.
4. Geometry and measurement curriculum and problem solving (3-4 weeks)
5. Algebra curriculum and problem solving (3-4 weeks)
6. Rational numbers curriculum and problem solving (3-4 weeks)
7. Data and probability curriculum and problem solving (3-4 weeks)

MTH 331 **Title** Euclidean Geometry

Description Critical analysis of Euclidean geometry from transformational, algebraic, and synthetic perspectives. Coordinate and vector geometry relating transformational geometry to linear algebra. Informal study of historical development of Euclidean and non-Euclidean geometries and the questions relating to the parallel postulate to develop understanding of axiomatic systems.

Objectives: After successful completion of the course, students will be able to…

1. Identify key results about triangles and circles in Euclidean geometry.
2. Write in a manner that further improves one's mathematical communication skills.
3. Identify connections between linear algebra and transformational geometry.
4. Develop an understanding of the fundamental concepts of axiomatic geometries.
5. Identify the role of neutral geometry and the parallel postulate in the development of Euclidean geometry.

Topics

1. Axiomatic Systems (2 weeks)
   - Properties of axiomatic systems
   - Finite geometries
2. Neutral Geometry (3 weeks)
   - Congruence conditions
   - Quadrilaterals and angle sums
3. Euclidean Geometry (6 weeks)
   - Parallel postulate
   - Congruence and area
   - Similarity
   - Theorems for circles and triangles
   - History and development of Euclidean geometry
4. Transformational Geometry (3 weeks)
   - Isometries and similarities
   - Applications of linear algebra

MTH 350 **Title** Modern Algebra I

Description: Algebraic properties of the integers and the development of the rational, real, and complex number systems as algebraic structures. Topics from modern algebra include rings, integral domains, fields, and ring isomorphisms. Further study of algebraic structures using congruence arithmetic and factorization in the ring of integers and polynomial rings.

Objectives: After successful completion of the course, students will be able to…

1. Write to communicate the topics of abstract algebra using accepted proof writing conventions, explanations, and correct mathematical notation.
2. Identify fundamental structures of abstract algebra including rings, fields, and integral domains.
3. Demonstrate problem solving skills in the context of abstract algebra topics through consideration of examples, pattern exploration, conjecture, proof construction, and generalization of results.
4. Analyze similarities and differences between algebraic structures including rings, fields, and integral domains.

Topics

1. Elementary number theory (3 weeks)
   - Divisibility of integers, prime factorization, division algorithm
   - Greatest common divisors, including using the the Euclidean algorithm
   - Bezout's identity
2. Equivalence relations (1-2 weeks)
   - Reflexivity, symmetry, transitivity
   - Congruence classes of integers modulo n
3. Rings (4-5 weeks)
   - Definitions of rings, integral domains, fields
   - Examples including some of the following: subsets of real and complex numbers, 2x2 matrices with real entries, integers mod n
   - Zero divisors and units
   - Characteristic of a ring
4. Relationships between rings (2-3 weeks)
   - Subrings
   - Ring homomorphisms and ring isomorphisms
   - Relationships between fields and integral domains
5. Polynomial rings (1-2 weeks)
   - Factorizations of polynomials, irreducible polynomials
   - Relationships between polynomials over a field and other rings

MTH 360 Course Title: Operations Research

Description: Mathematical modeling under conditions of certainty and uncertainty. Linear programming, duality, and sensitivity analysis. Markov chains and other stochastic processes. Applications to problems in transportation, scheduling, and resource allocation.

Objectives: After successful completion of the course, students will be able to…

1. Formulate mathematical models of mathematical programming problems.
2. Apply operations research techniques such as the simplex method and interior point algorithms to solve linear programming problems.
3. Apply concepts from linear algebra, geometry, and calculus to understand the logical basis for operations research techniques.
4. Use operations research techniques to investigate problems inspired by real-world problems, such as optimization, scheduling, and network routing.
5. Use duality and sensitivity analysis to analyze solutions to linear programming problems.

Topics

1. Linear programming (1-2 weeks)
2. The simplex algorithm (2-3 weeks)
3. Applications of linear programming (2-3 weeks)
4. Duality and sensitivity analysis (2-3 weeks)
5. Integer linear programming (2-3 weeks)
6. Additional Topics (may include nonlinear programming, numeric methods, constrained nonlinear problems)

MTH 386 Course Title: Study Abroad in Mathematics Education

Description: Of varying focus, the course makes use of the history, culture, and society of a host country in order to highlight mathematics education perspectives in context. To be taught in that country (or countries) as part of an approved study abroad program.

Objectives: After successful completion of the course, students will be able to…

1. Discuss relevant issues in the country of travel related to the focus of the course (e.g., STEM education, gender inequity, language, and addressing students with special needs in Tanzania)
2. Compare these relevant issues in the country of travel with similar issues in the United States.
3. Analyze the source of these issues in the country of travel and evaluate possible solutions to these issues.

Topics

Topics for this course will depend on the country of travel, as different regions of the world face varying issues that impact their population.

MTH 387 Course Title: Study Abroad in Mathematics

Description: Of varying focus, the course makes use of the history, culture, and society of a host country in order to highlight mathematics perspectives in context. To be taught in that country (or countries) as part of an approved study abroad program. By permit only. Credit may vary.

Objectives: After successful completion of the course, students will be able to…

1. Discuss relevant issues in the country of travel related to the focus of the course.
2. Compare these relevant issues in the country of travel with similar issues in the United States.
3. Analyze the source of these issues in the country of travel and evaluate possible solutions to these issues.

Topics

Topics for this course will depend on the country of travel, as different regions of the world face varying issues that impact their population.

MTH 401 Course Title: Mathematics for the Physical Sciences

Description: An introduction to the mathematics most relevant for the physical sciences and physical problems that demonstrate its need. Topics include vector analysis, including line and surface integrals, complex differentiable functions, and partial differential equations and Sturm-Liouville problems.

Objectives: After successful completion of the course, students will be able to…

1. Evaluate line integrals of vector fields directly using parametrization of the curve.
2. Apply the Fundamental Theorem of Line Integrals to evaluate line integrals.
3. Compute physical quantities, such as work, using line integrals.
4. Evaluate surface integrals of vector fields using a parametrization of the surface.
5. Apply Stokes' Theorem or the divergence theorem to evaluate surface integrals.
6. Compute physical quantities, such as flux, using surface integrals.
7. Identify complex differentiable functions.
8. Compute line integrals of complex differentiable functions.

9. Apply Cauchy's theorem and use of residues to evaluate line integrals of complex differentiable functions.
10. Apply complex differentiable function theory to solve problems in two-dimensional electrostatics and fluid flow.
11. Describe the physical origins of some partial differential equations, such as the heat and wave equations.
12. Apply separation of variables and Sturm-Liouville theory, including Fourier analysis, to find explicit solutions to partial differential equations.
13. Utilize special mathematical functions, such as Legendre polynomials and Bessel functions, in the solution of physical problems.

Topics

1. Line Integrals and Work: Parametrization of curves and the evaluation of line integrals, The Fundamental theorem of line integrals, work and potential functions. (2 weeks)
2. Surface integrals and flux: Parametrization of surfaces and the evaluation of surface integrals, Stokes' theorem and the divergence theorem, applications to fluid flow and electricity and magnetism, Maxwell's equations. (3 weeks).
3. Complex differentiable functions: Complex functions and differentiability, line integrals of complex functions, the Polya vector field, Cauchy's theorem and residues, applications to electrostatics and fluid flow. (3 weeks)
4. Partial Differential Equations: The origin of the heat and wave equations, separation of variables and elementary Fourier analysis, higher dimensional equations and elementary Sturm-Liouville theory, the Fourier Transform, Special functions. (6 weeks)

MTH 402 Course Title: Complex Variables

Description: Complex arithmetic derivatives and integrals of functions of a complex variable. Infinite series. Residue calculus. Applications to real integration and fluid flows.

Objectives: After successful completion of the course, students will be able to…

1. Define and explain complex numbers and their basic topology.
2. Compute operations on complex numbers.
3. Describe conformal mappings.
4. Verify analyticity of functions.
5. Apply the Cauchy-Riemann equations to test for differentiability.
6. Expand functions in Taylor and Laurent series.
7. Apply Cauchy's Integral Formula to evaluate complex line integrals.
8. Apply the Residue Theorem to evaluate real integrals.

Topics

1. Complex numbers, including their basic topology. Operations with complex numbers in both standard and exponential forms (approx. 3 weeks).
2. Complex functions and basic mapping properties (approx. 3 weeks).
3. Analyticity and the Cauchy-Riemann equations (approx. 2 weeks).
4. Contour integration, Cauchy theorem and Cauchy integral formula (approx. 2 weeks).
5. Taylor and Laurent theorems; Classification of singularities (approx. 2 weeks).
6. Residue Calculus: evaluation of integrals (approx. 2 weeks).

MTH 405 Course Title: Numerical Analysis

Description: Numerical methods in solving equations of a single variable, matrix algebra, numerical differentiation and integration, numerical solution to differential equations, polynomial approximations, and error estimates.

Objectives: After successful completion of the course, students will be able to…

1. Adapt numerical methods to approximate solutions to various equations.
2. Develop interpolating functions that fit a data set
3. Develop numerical methods to approximate a definite integral
4. Develop numerical methods to approximation the solution to an initial value problem
5. Produce an error analysis for various numerical methods.
6. Synthesize error analyses into algorithms that accelerate convergence
7. Write various numerical methods in a modern computer language.

Topics

1. Preliminaries of Computing -- 1 week
    - Round-off error and floating point arithmetic
    - Convergence
2. Numerical Solutions of Nonlinear Equations – 2 weeks
    - Bisection method, fixed point iteration, Newton's method
    - Error analysis for iterative methods
    - Accelerating convergence
3. Interpolation and Polynomial Approximation – 3 weeks
    - Lagrange interpolation
    - Divided differences
    - Hermite interpolation
    - Cubic spline interpolation
4. Numerical Differentiation and Integration– 4 weeks
    - Numerical differentiation
    - Richardson extrapolation
    - Composite numerical integration
    - Romberg integration
    - Adaptive quadrature methods
    - Gaussian quadrature
5. Ordinary Differential Equations and Initial Value Problems– 4 weeks
    - Euler's method and higher-order Taylor methods
    - Runge-Kutta methods
    - Multistep methods
    - Variable step-size multistep methods
    - Extrapolation methods
    - Stability

MTH 408 Course Title: Advanced Calculus I

Description: Techniques of proof, development of the real number system and its topology, a rigorous examination of limits, continuity, differentiation, and integration of functions on one real variable. Also a development of techniques for solving problems not treated in an elementary calculus sequence.

Objectives: After successful completion of the course, students will be able to…

1. State, explain, and apply the completeness, Archimedean, and density properties of the set of real numbers.
2. Define, explain, and compute infima and suprema of sets of real numbers.
3. Apply the definitions related to sequences to proving and deriving results about sequences.
4. Apply the definitions related to limits of functions to proving results on limits.
5. Determine and prove whether a given function is uniformly continuous on a given domain.
6. Explain what it means for a function to be differentiable.
7. Apply the Mean Value Theorem, Rolle's Theorem and related results to solve a variety of problems.
8. Define and determine the Riemann integrablity of a function on a given interval.

Topics

1. The real number system (approx. 2 weeks)
2. Sequences (approx. 3 weeks)
3. Limits of functions (approx. 2 weeks)
4. Continuous functions (approx. 2 weeks)
5. Uniform continuity (approx. 1 week)
6. Differentiable functions (approx. 2 weeks)
7. Riemann integral (approx. 2 weeks)

MTH 409 Course Title: Advanced Calculus II

Description: Infinite series, improper integrals, development of the topology of Euclidean n-space and rigorous examination of limits, continuity, and differentiability of functions of several variables.

Objectives: After successful completion of the course, students will be able to…

1. Define and determine differentiability of a function.
2. Apply the Mean Value Theorem, Rolle's Theorem and related results to solve a variety of problems.
3. Define and determine the Riemann integrablity of a function on a given interval.
4. Explain what it means for a set to be measurable in the Lebesgue Measure.
5. Define and determine the Lebesgue integrablity of a function.
6. Explain the difference between Riemann and Lebesgue Integrations.
7. Explain the definitions and properties related to the convergence of sequences and series of functions and use them to prove results about sequences and series.
8. Determine the conditions necessary and sufficient to guarantee commutativity between limit, integral, and summation operations.

Topics

1. Differentiable functions (approx. 2 weeks)
2. Riemann integral (approx. 3 weeks)
3. Lebesgue Integral (approx. 3 weeks)
4. Sequence of Functions (approx. 3 weeks)
5. Series of Functions (approx. 3 weeks)

MTH 431 Course Title: Non-Euclidean Geometry

Description: A critical examination of several non-Euclidean geometries, including finite geometries, hyperbolic geometry, and spherical geometry; their relationships to Euclidean geometry; and the historical and philosophical significance of the development of non-Euclidean geometries.

Objectives: After successful completion of the course, students will be able to…

1. Write in a manner that further improves one's mathematical communication skills.
2. Compare and contrast various non-Euclidean geometries with each other and with Euclidean geometry.
3. Create conjectures about non-Euclidean geometries based upon experimentation and create logically valid, well-written proofs or counterexamples to determine the validity of those conjectures
4. Demonstrate the capability to understand and apply abstract mathematical concepts.

Topics

1. Axiomatic Systems – 2 weeks
   - Properties
   - Incidence geometries
   - Parallel Axiom Alternatives
   - Finite geometries
2. Development of Non-Euclidean Geometry – 2 weeks
   - History
   - Philosophical implications
3. Hyperbolic Geometry (including the relationship to Euclidean Geometry) – 4 weeks
4. Spherical Geometry (including the relationships to Euclidean Geometry & Hyperbolic Geometry) – 4 weeks
5. Other Non-Euclidean Geometries (e.g., Projective Geometry, Minkowski Geometry, Taxi-cab Geometry, Spider Geometry) – 2 weeks

MTH 441 Course Title: Topology

Description: An introduction to the fundamental concepts of topology. The topology of the real number system and its generalizations to metric spaces and topological spaces. Topics include subspaces, neighborhood spaces, open and closed sets, interior and boundary of sets, continuity and homeomorphisms, connected and locally connected spaces, compact sets and spaces. Offered winter semester of odd-numbered years.

Objectives: After successful completion of the course, students will be able to…

1. State the definition of a topology and a basis for a topology on a set of objects.

2. State the definition of several common topologies on a set of objects. Common topologies could include subspace, discrete, indiscrete, and finite-closed.
3. Given a topology on a set of objects and a set, students will be able to determine the closure, interior, and limit points of the set in the topology.
4. Given a topology on a set of objects students will be able to determine various properties of the topology. Properties could include Hausdorff or path connected or connected or compact.
5. Apply the definition of a homeomorphism to proving two topological spaces are homeomorphic.
6. Apply the notion of an invariant to prove that two topological spaces are not homeomorphic.

Topics:

1. Introduction to topological spaces (3-4 weeks)
2. Properties of topologies (3-4 weeks)
3. Homeomorphisms between topological spaces (3-4) weeks
4. Discretionary topics (3-4 weeks)

MTH 450 Course Title Modern Algebra II

Description An introduction to groups, including homomorphisms and isomorphisms, Lagrange's Theorem, quotient groups, finite groups, and the Sylow theorems. Additional topics from ring theory including polynomial rings, ideals, and quotient rings.

Objectives: After successful completion of the course, students will be able to…

1. Write in a manner that further improves one's mathematical communication skills.
2. Develop the capability to understand and apply abstract mathematical ideas.
3. Develop an understanding of algebraic ideas in a variety of mathematical contexts.
4. Analyze fundamental concepts in the theories of rings and finite groups.

Topics

1. Introduction to groups (4-5 weeks)
    - Symmetries of geometric objects
    - Dihedral and symmetric groups
    - Group multiplication tables
    - Integer powers of group elements
2. Subgroups and quotient groups (3-4 weeks)
    - Cyclic subgroups
    - Normal subgroups
    - Cosets and Lagrange's theorem
    - Quotient groups
3. Mappings of groups (2-3 weeks)
    - Homomorphisms and kernels
    - Isomorphism theorems

Discretionary Topics:

Sylow's Theorems (1-2 weeks)

Topics in ring theory (1-2 weeks)

- Ideals and ring homomorphisms
- Quotient rings
- Polynomial rings

MTH 465 Course Title: Automata and Theory of Computation

Description: Introduction to basic mathematical models of computation and the finite representation of infinite objects. Finite automata, regular languages, nondeterminism, pushdown automata, context-free languages, Turing machines and variants, halting problems, time complexity of algorithms, and NP-Complete problems. Crosslisted with CIS 465.

Objectives: After successful completion of the course, students will be able to…

1. Analyze a deterministic or non-deterministic finite automaton and determine the language that it accepts.
2. Analyze a pushdown automaton and determine the language that it accepts
3. Analyze a Turing machine (or equivalently powerful variants) given its informal description and determine the language it accepts.
4. Describe the impact of the Halting problem on the limits of digital computing.
5. Compare the differences between P and NP problems and describe the role that NP-complete problems play in this difference.

Topics

1. Regular languages, regular expressions, deterministic finite automata, non-deterministic finite automata (3-4 weeks)
2. Context free languages, context-free grammars, and pushdown automata (3-4 weeks)
3. Turing machines (and variants), Turing recognizable languages, Turing decidable languages, and the Halting problem (4-5 weeks)
4. Time complexity analysis, P versus NP, and NP-Complete (2-3 weeks)

MTH 495 Course Title: The Nature of Modern Mathematics (Capstone)

Description: A study of mathematics as a human intellectual endeavor impacting our culture, history, and philosophy. Includes an in-depth investigation, including analyses from the mathematical, historical, and philosophical perspectives, of several significant developments from various fields of mathematics.

Objectives: After successful completion of the course, students will be able to…

1. Discuss the nature of mathematics and what it means to do mathematics, using specific examples to support their claims.
2. Explain mathematical underpinnings and philosophical foundations of mathematics.
3. Describe the impact of philosophical crises/discoveries (such as the independence of Euclid's parallel postulate) on the advancement of mathematics.
4. Discuss the impact of the humanity of mathematicians on the advancement of mathematics

Topics

Content of the course should include topics from the history of mathematics, philosophy, and modern developments in mathematics that illustrate the nature of the modern intellectual endeavor that is mathematics. Topics could include

1. Evolution of Number Systems and Numeration Systems. (1-2 weeks)
2. Axiomatic Systems and Foundations of Mathematics. (1-2 weeks).
3. The Greek geometric construction "Great Problems of Antiquity", and their modern interpretations, and their importance (squaring the circle, doubling the cube, trisecting an angle, and their relationship to rational, constructible, algebraic, and transcendental numbers; the transcendence of pi, constructability of square roots, but not cube roots, etc.). (~2 weeks)

MTH 496 Course Title: Senior Thesis (Capstone)

Description: A senior thesis is written to demonstrate depth and sophistication in the major. Independent library research is conducted under the supervision of a faculty member. Students produce full-fledged, professional, oral and written presentations on this research.

Objectives: After successful completion of the course, students will be able to…

1. Use research methodologies relevant to selected topic and field.
2. Demonstrate pedagogical or content use of understanding.
3. Demonstrate through written work and/or oral presentation professional communication of results in appropriate venue.

Topics

Varies by project.

MTH 498 MTH 498 Course Title: Project-Based Applied Mathematics (Capstone)

Description: Teams of students will solve real-world problems originating in business, industry, or government. Teams will research and analyze solution strategies, implement a strategy using software, interpret their findings, and communicate their results to their partner. Communication in a business environment, teamwork, and project planning will be emphasized.

Objectives: After successful completion of the course, students will be able to…

1) Analyze a mathematical problem originating with a partner from the business, industry, government, or non-profit sector.
2) Create a mathematical model of the problem using an appropriate mathematical framework.
3) Determine strategies for solving the problem, and analyze and evaluate different strategies.
4) Apply an appropriate solution strategy using appropriate software.
5) Plan and organize the work of a team toward meeting both short- and long-term goals.
6) Create a final report detailing the team's work on the problem and the results obtained.
7) Create and deliver an oral presentation detailing the team's work on the problem and the results obtained.

Topics

1. Introduction to problem (1-2 weeks)
2. Development and analysis of solution strategies (4-5 weeks) Implementation of solution strategy (4-5 weeks)
3. Analysis and synthesis of results (2-3 weeks)
4. Presentation of results (1-2 weeks)

MTH 625 Course Title: Number Theory

Description: The mathematical treatment of the properties and the structure of the set of integers. Topics include prime numbers, divisibility, number-theoretic functions, the algebra of congruence classes, and applications.

Objectives: After successful completion of the course, students will be able to…

1. Write in a manner that further improves one's mathematical communication skills.
2. Solve linear Diophantine equations using appropriate number-theoretic techniques.
3. Demonstrate an understanding of the fundamental properties and the structure of the set of integers.
4. Demonstrate problem solving skills in the context of number theory topics through consideration of examples, pattern exploration, conjecture, proof construction, and generalization of results.
5. Create logically valid, well-written proofs for number theoretic results.

Topics

1 Divisibility Properties– 5 weeks
- Prime & Composite Numbers
- The Greatest Common Divisor
- The Least Common Multiple
- The Generalized GCD & LCM
- Linear Diophantine Equations
- The Fundamental Theorem of Arithmetic
- Perfect Numbers
- Mersenne Primes

2 Number Theoretic Functions (including the Euler φ-Function) – 2 weeks

3 Congruence Theory– 5 weeks
- Congruence Theorems
- Reduced Residue Systems
- Euler's Theorems
- Fermat's Theorems
- Linear Congruences
- Wilson's Theorem
- Linear Congruences in Two Variables
- The Chinese Remainder Theorem

4. Additional Topics (e.g., Public Key Encryption, Elliptic Curves) – 2 weeks

MTH 641 Course Title: Modern Geometry

Description: The study of geometry as a mathematical system, explorations of different geometries and their relations to physical space and as sources of mathematical models, investigations of geometrical thinking in problem solving in mathematics and areas outside of mathematics. Computer applications appropriate to school classrooms.

Objectives: After successful completion of the course, students will be able to…

1. Write in a manner that further improves one's mathematical communication skills.
2. Compare and contrast various geometries.
3. Identify connections between various geometries and physical space.
4. Demonstrate an understanding of the fundamental concepts of axiomatic geometries.

5. Create conjectures about various geometries based upon experimentation and create logically valid, well-written proofs or counterexamples to determine the validity of those conjectures.
6. Employ effective problem-solving skills in solving a variety of problems using various geometric models.

Topics

1. Axiomatic Systems – 2 weeks
   - Properties
   - Incidence geometries
   - Parallel Axiom Alternatives
   - Finite geometries
2. Euclidean Geometry – 3 weeks
   - Investigations with *Geogebra*/*Geometer's Sketchpad* and manipulatives
   - Models
   - Applications
3. Hyperbolic Geometry – 2 weeks
   - Investigations with *Geogebra*/*Geometer's Sketchpad* and manipulatives
   - Models
   - Applications
4. Projective Geometry – 3 weeks
   - Investigations with *Geogebra*/*Geometer's Sketchpad* and manipulatives
   - Models
   - Applications
   - Other Geometries
5. Other Geometries (e.g., Taxi-Cab, Spider, Minkowski) – 3 weeks
   - Investigations with *Geogebra*/*Geometer's Sketchpad* and manipulatives
   - Models
   - Applications
6. Compare/Contrast the above Geometries – 1 week

MTH 680 Title of Course: Special Topics

Description: Readings, lecture, discussion, or lab (or any combination) in specific topics in mathematics education.

Objectives:

For math versions, upon completion of this course students will be able to:

1. Analyze the mathematical ideas and reasoning related to course topics,
2. Apply the mathematical results and reasoning to new situations, and
3. Apply the mathematical results and reasoning to real-world settings (when applicable).

For math education versions, upon completion of this course students will be able to:

1. Synthesize and critique literature related to students' understanding of the mathematical and educational topics.
2. Integrate the research findings into their own practice.

Topics

Course topics will vary according to the special requirements of the content to be addressed in the course.