Department of Mathematics

The Department of Mathematics offers a major in mathematics that culminates in a bachelor of science (BS) degree. The department also offers minors in mathematics and mathematical statistics, as well as mathematics education in the College of Education.

Mathematics Major

Degree Requirements

Students earning the bachelor of science (BS) degree with a major in mathematics must complete all University, college and departmental degree requirements. These include the general education requirements, the following major requirements, all requirements for an approved minor, and other sufficient credits to total a minimum of 120 applicable semester hours.

Admission into the Major

Students are expected to formally declare a major no later than the fourth semester of full-time enrollment (or at 61 semester hours for transfer students). Students may declare a major by completing the Change of Major/Minor Application online under the Student tab of myBama.

Grade Point Average

A 2.0 grade point average in the major is required for completion of the degree. Please see the Grade Point Average (GPA) section of this catalog for an explanation on grade point average calculations.

Major Courses

The major in mathematics requires the successful completion of 36-37 semester hours, including the core mathematics courses, a specific track and ancillary courses.

Core Mathematics Courses

The following courses must be completed by all mathematics majors:

- **Core Courses**
  - MATH 125 or Calculus I (4)
  - MATH 145 Honors Calculus I (4)
  - MATH 126 or Calculus II (4)
  - MATH 146 Honors Calculus II (4)
  - MATH 227 or Calculus III (4)
  - MATH 247 Honors Calculus III (4)
  - MATH 237 Introduction to Linear Algebra (3)
  - MATH 238 Appl Diff Equations I (3)
  - MATH 301 Discrete Mathematics (3)
  - **Total Hours**: 21

- **Pure Mathematics Track**
  - Core mathematics courses (21)
  - MATH 470 Prin Modern Algebra I (3)
  - MATH 485 Intro Complex Variables (3)
  - MATH 486 Introduction to Real Analysis I (3)
  - Select two of the following: (6)
    - MATH 371 Advanced Linear Algebra
    - MATH 465 Intro General Topology
    - MATH 471 Prin Modern Algebra II
    - MATH 487 Intro to Real Analysis II
  - **Total Hours**: 36

- **Applied Mathematics – Scientific Computation Track**
  - Core mathematics courses (21)
  - MATH 300 Intro Numerical Analysis (3)
  - MATH 343 Appl Diff Equations II (3)
  - MATH 410 Numerical Linear Algebra (3)
  - Select two of the following: (6)
    - MATH 355 Theory Of Probability
    - MATH 420 Linear Optimization Theory
    - MATH 421 Non-Linear Optimization Theory
  - **Total Hours**: 37

- **Applied Mathematics – Classical Track**
  - Core mathematics courses (21)
  - MATH 300 Intro Numerical Analysis (3)
  - MATH 343 Appl Diff Equations II (3)
  - MATH 410 Boundary Value Problems (3)
  - MATH 485 Intro Complex Variables (3)
  - Select one of the following: (3)
    - MATH 410 Numerical Linear Algebra
    - MATH 442 Integral Transf & Asympt
    - MATH 486 Introduction to Real Analysis I
  - **Total Hours**: 36

- **Applied Mathematics – Optimization Track**
  - Core mathematics courses (21)
  - MATH 300 Intro Numerical Analysis (3)
  - MATH 355 Theory Of Probability (3)
  - MATH 410 Numerical Linear Algebra (3)
  - Select two of the following: (6)
    - MATH 419
    - MATH 420 Linear Optimization Theory
    - MATH 421 Non-Linear Optimization Theory
  - **Total Hours**: 36

- **Mathematical Statistics Track**
  - Core mathematics courses (21)
  - MATH 300 Intro Numerical Analysis (3)
  - MATH 355 Theory Of Probability (3)
  - MATH 451 Math Stats W/Applictn I (3)
  - MATH 452 Math Stats W/Applictn II (3)
  - Select one of the following: (3)
    - MATH 422 Mathematics For Finance I
    - MATH 457 Stochastic Processes I
    - MATH 486 Introduction to Real Analysis I
  - **Total Hours**: 36

- **Mathematics Education Track**
  - Core mathematics courses (21)
  - MATH 355 Theory Of Probability (3)
  - MATH 403 Adv Math Connections & Devlpnm (3)
  - MATH 404 Topics Math Secondary Teachers (1)
  - MATH 405 Geometry For Teachers (3)
  - MATH 470 Prin Modern Algebra I (3)
  - MATH 486 Introduction to Real Analysis I (3)
  - **Total Hours**: 37

*This track is open to all students and should be followed by those planning to enter the teaching profession in the future. Please note that this track does not lead to teacher certification. Students interested in earning teacher certification must be admitted through the College of Education. For more information, visit [http://courseleaf.ua.edu/education/curriculumandinstruction/#secondaryeducationtext](http://courseleaf.ua.edu/education/curriculumandinstruction/#secondaryeducationtext).*
Ancillary Courses

Grades in ancillary courses are not computed into the major GPA. The major in mathematics for all tracks requires the successful completion of the following (2) courses outside the major:

### Ancillary Courses

Select One of the Following Courses:
- CS 100 Computer Science Principles
- CS 104 Programming I
- CS 250 Programming II
- CS 101 CS II for Majors
- CS 250 Programming II
- ST 260 Statistical Data Analysis

### Upper-level Residency

A minimum of 12 hours of 300- or 400-level courses in the major must be earned on this campus.

### Required Minor

The mathematics minor requires the completion of a minor.

### Additional Major Requirements

Students are responsible for ensuring that they have met all University, College, major and minor requirements. However, each student must meet with an adviser in the major department for academic planning and to be approved for registration each semester. College advisers are also available for additional assistance with minor, College and University requirements.

### Special Opportunities

Mathematics majors can complete a second major in computer science, electrical engineering, economics or finance, among others. On campus employment as a math tutor in the Mathematics Technology Learning Center is available to qualified undergraduate mathematics majors. Research experiences are possible for advanced undergraduate students. The University of Alabama also has a chapter of Pi Mu Epsilon, a national mathematics honor society. The Department of Mathematics participates in the University Scholars Program, allowing highly motivated students to pursue closely integrated undergraduate and graduate programs that may lead to the simultaneous completion of requirements for both master’s and bachelor’s degrees. Students usually apply for admission prior to the junior or senior year. For more information about the University Scholars Program, visit graduate.ua.edu or consult the University of Alabama Graduate Catalog.

### Mathematics Minor

#### Admission into the Minor

Students are expected to formally declare a minor by completing the Change of Major/Minor Application online under the Student tab of myBama.

#### Grade Point Average

A 2.0 grade point average in the minor is required. Please see the Grade Point Average (GPA) section of this catalog for an explanation on grade point average calculations.

#### Minor Courses

The minor in mathematical statistics requires the successful completion of the following 21 semester hours:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 125 or Calculus I</td>
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</tr>
<tr>
<td>MATH 247 Honors Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 237 Introduction to Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 355 Theory Of Probability</td>
<td>3</td>
</tr>
<tr>
<td>MATH 451 Math Stats W/Applictn I</td>
<td>3</td>
</tr>
<tr>
<td>Total Hours</td>
<td>21</td>
</tr>
</tbody>
</table>

### Upper-level Residency

A minimum of six hours of 300- or 400-level courses in the minor must be earned on this campus.

### Ancillary Courses

This minor does not require ancillary courses.

### Additional Minor Requirements

Students are responsible for ensuring that they have met all University, College, major and minor requirements. However, each student must meet with an adviser in the major department for academic planning and to be approved for registration each semester. College advisers are also available for additional assistance with minor, College and University requirements.

### Mathematical Statistics Minor

#### Admission into the Minor

Students are expected to formally declare a minor by completing the Change of Major/Minor Application online under the Student tab of myBama.

#### Grade Point Average

A 2.0 grade point average in the minor is required. Please see the Grade Point Average (GPA) section of this catalog for an explanation on grade point average calculations.

#### Minor Courses

The minor in mathematics requires the successful completion of the following 21 semester hours:

<table>
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<tr>
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<td>4</td>
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<td>4</td>
</tr>
<tr>
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<td>3</td>
</tr>
<tr>
<td>MATH 355 Theory Of Probability</td>
<td>3</td>
</tr>
<tr>
<td>MATH 451 Math Stats W/Applictn I</td>
<td>3</td>
</tr>
<tr>
<td>Total Hours</td>
<td>21</td>
</tr>
</tbody>
</table>

### Upper-level Residency

A minimum of six hours of 300- or 400-level courses in the minor must be earned on this campus.

### Ancillary Courses

This minor does not require ancillary courses.

### Additional Minor Requirements

Students are responsible for ensuring that they have met all University, College, major and minor requirements. However, each student must meet with an adviser in the major department for academic planning and to be approved for registration each semester. College advisers are also available for additional assistance with minor, College and University requirements.
Admission into the Minor

To be eligible for the mathematics education minor, a student must major in mathematics (mathematics education track). Students are expected to formally declare this minor through the College of Education.

Grade Point Average

A 2.0 grade point average in the minor is required for completion of the degree. Please see the Grade Point Average (GPA) section of this catalog for an explanation on grade point average calculations.

Minor Courses

The minor in mathematics education requires the successful completion of the following 20 semester hours:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDU 200</td>
<td>Orient to Teacher Education</td>
<td>1</td>
</tr>
<tr>
<td>SPE 300</td>
<td>Survey Spe Accomd Strag</td>
<td>3</td>
</tr>
<tr>
<td>BEP 360</td>
<td>Social Psychol Foundtns Educ</td>
<td>3</td>
</tr>
<tr>
<td>CSE 390</td>
<td>Instructn Accomd Sec Sch</td>
<td>3</td>
</tr>
<tr>
<td>CSE 401</td>
<td>Tech for Teaching Sec. Math</td>
<td>3</td>
</tr>
<tr>
<td>CSE 406</td>
<td>Curriculum Secondary Math</td>
<td>3</td>
</tr>
<tr>
<td>CSE 493</td>
<td>Diversity Block Seminar</td>
<td>1</td>
</tr>
<tr>
<td>Electives: Choose 3 hours from the following</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT 200</td>
<td>Computer Education Application</td>
<td>3</td>
</tr>
<tr>
<td>CAT 250</td>
<td>Computer Educ Curric Devel</td>
<td></td>
</tr>
<tr>
<td>EDU 401</td>
<td>Dyn. of American Ed: Honors</td>
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<tr>
<td>EDU 402</td>
<td>Honors Educational Diversity and Advocacy</td>
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</tr>
<tr>
<td>EDU 403</td>
<td>Honors Educational Policy</td>
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<td>HD 401</td>
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<td>HD 412</td>
<td>Adult Development</td>
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<tr>
<td>SPE 302</td>
<td>Educatl Diagn Measurmt</td>
<td></td>
</tr>
<tr>
<td>SPE 382</td>
<td>Teaching Thinking Skills</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 20

Upper-level Residency

A minimum of six hours of 300- or 400-level courses in the minor must be earned on this campus.

Ancillary Courses

This minor does not require ancillary courses.

Additional Minor Requirements

Students are responsible for ensuring that they have met all University, College, major and minor requirements. However, each student must meet with an adviser in the major department for academic planning and to be approved for registration each semester. College advisers are also available for additional assistance with minor, College and University requirements.

Faculty

Chair and Professor
Hsia, Wei Shen

Professors
Allen, Paul J.
Corson, Jon M.
Dixon, Martyn R.
Evans, Martin
Hadj, Layachi
Halpern, David C. M. J.
Liem, Vo Thanh
Moore, Robert L.
Neggers, Joseph
Olin, Robert F.
Sun, Min
Wang, James L.

Associate Professors
Belbas, Starvos
Gleason, Jim
Sidje, Roger
Trace, Bruce S.
Zhao, Shan
Zhu, Wei

Assistant Professors
Ames, Brendan
Benzosova, Oleksandra
Chen, Yuhui
Ferguson, Timothy
Kwon, Hyun
Lewis, Andrew
Moen, Kabe
Roberts, Lawrence
Song, Song

Courses

MATH 005. Introductory Algebra. 3 sem. hrs.
Brief review of arithmetic operations and basic algebraic concepts: factoring, operations with polynomials and rational expressions, linear equations and word problems, graphing linear equations, simplification of expressions involving radicals or negative exponents, and elementary work with quadratic equations. Grades are reported as pass/fail.

MATH 100. Intermediate Algebra. 3 sem. hrs.
Prerequisites: Placement and two units of college-preparatory mathematics; if a student has previously been placed in MATH 100, a grade of "C-" or higher in MATH 005 is required. Intermediate-level course including work on functions, graphs, linear equations and inequalities, quadratic equations, systems of equations, and operations with exponents and radicals. The solution of word problems is stressed. NOT APPLICABLE to UA Core Curriculum mathematics requirement. Grades are reported as A, B, C or NC (No Credit).
Prerequisite(s): UA Math Placement Test Score of 190 or higher or ACT Math Subscore of 18 or SAT Math Subscore of 440 or higher or MATH 005.

MATH 110. Finite Mathematics. 3 sem. hrs.
This course is intended to give an overview of topics in finite mathematics with applications. This course covers mathematics of finance, logic, set theory, elementary probability and statistics. This course does not provide sufficient background for students who will need to take Precalculus Algebra or Calculus.
Prerequisite(s): UA Math Placement Test Score of 190 or higher or ACT Math Subscore of 18 or SAT Math Subscore of 440 or higher or MATH 005.

MATH 112. Precalculus Algebra. 3 sem. hrs.
Prerequisites: Placement and three units of college-preparatory mathematics; if a student has previously been placed in MATH 100, a grade of "C-" or higher in MATH 100 is required. A higher-level course emphasizing functions including polynomial functions, rational functions, and the exponential and logarithmic functions. Graphs of these functions are stressed. The course also includes work on equations, inequalities, systems of equations, the binomial theorem, and the complex and rational roots of polynomials. Applications are stressed. Grades are reported as A, B, C or NC (No Credit).
Prerequisite(s): UA Math Placement Test Score of 310 or higher or ACT Math Subscore of 24 or SAT Math Subscore of 560 or MATH 100.

MATH 113. Precalculus Trigonometry. 3 sem. hrs.
Prerequisite: If a student has previously been placed into MATH 112, a grade of "C-" or higher in MATH 112 is required. Continuation of MATH 112. The course includes study of trigonometric functions, inverse trigonometric functions, trigonometric identities and trigonometric equations. Complex numbers, De Moivre’s Theorem, polar coordinates, vectors and other topics in algebra are also addressed, including conic sections, sequences and series. Grades are reported as A, B, C or NC (No Credit).
Prerequisite(s): MATH 112.
MATH 115. Precalc Algebra & Trig. 3 sem. hrs.
Prerequisite(s): Placement and a strong background in college-preparatory mathematics, including one-half unit in trigonometry. Properties and graphs of exponential, logarithmic, and trigonometric functions are emphasized. Also includes trigonometric identities, polynomial and rational functions, inequalities, systems of equations, vectors, and polar coordinates. Grades are reported as A, B, C, or NC (No credit). Degree credit will not be granted for both MATH 115 and MATH 112 or MATH 113.
Prerequisite(s): UA Math Placement Test Score of 380 or higher or ACT Math Subscore of 29 or SAT Math Subscore of 650.

MATH 121. Calculus & Applications. 3 sem. hrs.
Prerequisite(s): MATH 112 or equivalent. If a student has previously been placed in MATH 112, a grade of "C" or higher in MATH 112 is required. A brief overview of calculus primarily for students in the Culverhouse College of Commerce and Business Administration. This course does not provide sufficient background for students who will need higher levels of calculus. Note: This course does not satisfy the requirement for Math 125 or 126. Degree credit will not be granted for both MATH 121 and MATH 125 or MATH 145.
Prerequisite(s): (MATH 112 AND MATH 113) OR MATH 115.

MATH 125. Calculus I. 4 sem. hrs.
This is the first of three courses in the basic calculus sequence. Topics include the limit of a function; the derivative of algebraic, trigonometric, exponential, and logarithmic functions; and the definite integral. Applications of the derivative are covered in detail, including approximations of error using differentials, maxima and minima problems, and curve sketching using calculus. There is also a brief review of selected precalculus topics at the beginning of the course. Degree credit will not be granted for both MATH 121 and MATH 125 or MATH 145.
Prerequisite(s): MATH 113 and MATH 112; or MATH 115.

MATH 126. Calculus II. 4 sem. hrs.
This is the second of three courses in the basic calculus sequence. Topics include vectors and the geometry of space, applications of integration, integration techniques, L'Hopital's Rule, improper integrals, parametric equations, polar coordinates, conic sections and infinite series.
Prerequisite(s): MATH 125 or MATH 131 or MATH 145.

MATH 145. Honors Calculus I. 4 sem. hrs.
Honors sections of MATH 125.

MATH 146. Honors Calculus II. 4 sem. hrs.
Honors sections of MATH 126.
Prerequisite(s): MATH 125 or MATH 145.

MATH 208. Number And Operations. 3 sem. hrs.
Arithmetic of whole numbers and integers, fractions, proportion and ratio, and place value. Class activities initiate investigations underlying mathematical structure in arithmetic processes and include hands-on manipulatives for modeling solutions. Emphasis is on the explanation of the mathematical thought process. Students are required to verbalize explanations and thought processes and to write reflections on assigned readings on the teaching and learning of mathematics.
Prerequisite(s): MATH 100 or MATH 110 or MATH 112.

MATH 209. Geometry & Measurement. 3 sem. hrs.
Properties of two- and three-dimensional shapes, rigid motion transformations, similarity, spatial reasoning, and the process and techniques of measurement. Class activities initiate investigations of underlying mathematical structure in the exploration of shape and space. Emphasis is on the explanation of the mathematical thought process. Technology specifically designed to facilitate geometric explorations is integrated throughout the course.
Prerequisite(s): MATH 208.

MATH 210. Data Analysis Probabil Stats. 3 sem. hrs.
Data analysis, statistics, and probability, including collecting, displaying/representing, exploring, and interpreting data, probability models, and applications. Focus is on statistics for problem solving and decision making, rather than calculation. Class activities deepen the understanding of fundamental issues in learning to work with data. Technology specifically designed for data-driven investigations and statistical analysis is integrated throughout the course.
Prerequisite(s): MATH 208.

MATH 227. Calculus III. 4 sem. hrs.
This is the third of three courses in the basic calculus sequence. Topics include: vector functions and motion in space; functions of two or more variables and their partial derivatives; and applications of partial derivatives (including Lagrange multipliers), quadric surfaces, multiple integration (including Jacobian), line integrals, Green's Theorem, vector analysis, surface integrals and Stokes' Theorem.
Prerequisite(s): MATH 146 or MATH 126 or MATH 132.

MATH 237. Introduction to Linear Algebra. 3 sem. hrs.
Fundamentals of linear algebra and matrix theory are covered. Topics include vectors in Euclidean spaces, solving systems of linear equations, matrix algebra, inverses, determinants, eigenvalues, and eigenvectors. Also vector spaces and the basic notions of span, subspace, linear independence, basis, dimension, linear transformations, kernel and range are considered. Use of linear algebra software is introduced. Theory plays a significant role in this course - both in lectures and tests.
Prerequisite(s): MATH 126 or MATH 146.

MATH 238. Appl Diff Equations I. 3 sem. hrs.
Introduction to analytic and numerical methods for solving differential equations. Topics include numerical methods and qualitative behavior of first order equations, analytic techniques for separable and linear equations, applications to population models and motion problems; techniques for solving higher order linear differential equations with constant coefficients (including undetermined coefficients, reduction of order, and variation of parameters), applications to physical models; the Laplace transform (including initial value problems with discontinuous forcing functions). Use of mathematics software is an integral part of the course.
Prerequisite(s): MATH 126 or MATH 146
Prerequisite(s) with concurrence: MATH 227 or MATH 247.

MATH 247. Honors Calculus III. 4 sem. hrs.
Honors sections of MATH 227.
Prerequisite(s): MATH 126 or MATH 132 or MATH 146.

MATH 300. Intro Numerical Analysis. 3 sem. hrs.
Credit will not be granted for both MATH 300 and MATH 411. A beginning course in numerical analysis. Topics include number representation in various bases, error analysis, location of roots of equations, numerical integration, interpolation and numerical differentiation, systems of linear equations, approximations by spline functions, and approximation methods for first-order ordinary differential equations and for systems of such equations.
Prerequisite(s): MATH 227 or MATH 247; and CS 100 or CS 104 or CS 150 or AEM 249 or ECE 285 or CBH 101.

MATH 301. Discrete Mathematics. 3 sem. hrs.
An introductory course that primarily covers logic, recursion, induction, modeling, algorithmic thinking, counting techniques, combinatorics, and graph theory. Writing proficiency within this discipline is required for a passing grade in this course.
Prerequisite(s): MATH 125 or MATH 145.

MATH 302. Topics in Discrete Mathematics. 1 sem. hr.
A supplemental course in discrete mathematics covering select topics of interest in computer science. Topics include graphs and trees, finite state automata and regular expressions, efficiency of algorithms.
Prerequisite(s): MATH 301.

MATH 343. Appl Diff Equations II. 3 sem. hrs.
Continuation of MATH 238. Topics include series solutions of differential equations, the method of Frobenius, Fourier series, method of separation of variables for partial differential equations, elementary boundary value problems for the Laplace, heat and wave equations, an introduction to Sturm-Liouville boundary value problems, and stability of autonomous systems. Usually offered in the spring semester.
Prerequisite(s): MATH 238.

MATH 355. Theory Of Probability. 3 sem. hrs.
The foundations of the theory of probability, laws governing random phenomena and their practical applications in other fields. Topics include: probability spaces; properties of probability set functions; conditional probability; and an introduction to combinatorics, discrete random variables, expectation of discrete random variables, Chebyshev's inequality, continuous variables and their distribution functions, and special densities.
Prerequisite(s): MATH 227 or MATH 247.

MATH 371. Advanced Linear Algebra. 3 sem. hrs.
Topics include inner product spaces, norms, self adjoint and normal operators, orthogonal and unitary operators, orthogonal projections and the spectral theorem, bilinear and quadratic forms, generalized eigenvectors, and Jordan canonical form.
Prerequisite(s): MATH 237.

MATH 382. Advanced Calculus. 3 sem. hrs.
Further study of calculus with emphasis on theory. Topics include limits and continuity of functions of several variables; partial derivatives; transformations and mappings; vector functions and fields; vector differential operators; the derivative of a function of several variables as a linear transformation; Jacobians; change of variables in multiple integrals; line and surface integrals; and Green's, Stokes', and Divergence Theorems.
Prerequisite(s): MATH 227 or MATH 247; and MATH 237.

MATH 402. History Of Mathematics. 3 sem. hrs.
Survey of the development of some of the central ideas of modern mathematics, with emphasis on the cultural context. Writing proficiency within this discipline is required for a passing grade in this course.
MATH 403. Adv Math Connections & Devlpmt. 3 sem. hrs.
Explore the interconnections between the algebraic, analytic, and geometric areas of mathematics with a focus on properties of various number systems, importance of functions, and the relationship of algebraic structures to solving analytic equations. This exploration will also include the development and sequential nature of each of these branches of mathematics and how it relates to the various levels within the algebraic mathematics curriculum.
Prerequisite(s): MATH 237 and MATH 301
Prerequisite(s) with concurrency: MATH 470 or MATH 486.

MATH 404. Topics Math Secondary Teachers. 1 sem. hr.
This is a seminar style course focusing on various mathematical topics related to the high school curriculum. Topics will vary depending upon instructor.
Prerequisite(s): MATH 301.

MATH 405. Geometry For Teachers. 3 sem. hrs.
This course will give an overview of geometry from a modern point of view. Both axiomatic and analytic approaches to geometry will be used. The construction of geometric proofs will play an important role.
Prerequisite(s): MATH 125 MATH 403 or department's permission.

MATH 410. Numerical Linear Algebra. 3 sem. hrs.
Further study of matrix theory, emphasizing computational aspects. Topics include direct solution of linear systems, analysis of errors in numerical methods for solving linear systems, least-squares problems, orthogonal and unitary transformations, eigenvalues and eigenvectors, and singular value decomposition.
Prerequisite(s): MATH 237 or MATH 257.

Credit will not be granted for both MATH 411 and MATH 300. A rigorous introduction to numerical methods, formal definition of algorithms, and error analysis and their implementation on a digital computer. Topics include interpolation, roots, linear equations, integration and differential equations, and orthogonal function approximation.
Prerequisite(s): MATH 237 or MATH 257; and MATH 238; and CS 150 or GES 126.

MATH 419. 3 sem. hrs.
A one-semester introduction to both linear and nonlinear programming for undergraduate students and non-math graduate students. Emphasis is on basic concepts and algorithms and the mathematical ideas behind them. Major topics in linear programming include the simplex method, duality, sensitivity analysis, and network problems; major topics in nonlinear programming include optimality conditions, several search algorithms for unconstrained problems, and a brief discussion of constrained problems. In-depth theoretical development and analysis are not included.
Prerequisite(s): MATH 237 or MATH 257.

MATH 420. Linear Optimization Theory. 3 sem. hrs.
In-depth theoretical development and analysis of linear programming. Topics include formulation of linear programs, various simplex methods, duality, sensitivity analysis, transportation and networks and various geometric concepts.
Prerequisite(s): MATH 237 or MATH 257.

MATH 421. Non-Linear Optimization Theory. 3 sem. hrs.
In-depth theoretical development and analysis of non linear programming with emphasis on traditional constrained and unconstrained non linear programming methods and an introduction to modern search algorithms.
Prerequisite(s): MATH 237 or MATH 257.

MATH 422. Mathematics For Finance I. 3 sem. hrs.
Topics include the basic no-arbitrage principle, binomial model, time value of money, money market, risky assets such as stocks, portfolio management, forward and future contracts, and interest rates.
Prerequisite(s): MATH 227 or MATH 247 and MATH 355.

MATH 432. Graph Theory & Applctns. 3 sem. hrs.
Survey of several of the main ideas of general theory with applications to network theory. Topics include oriented and non-oriented linear graphs, spanning trees, branching and connectivity, accessibility, planar graphs, networks and flows, matching, and applications.
Prerequisite(s): MATH 237 or MATH 257.

MATH 441. Boundary Value Problems. 3 sem. hrs.
Methods of solving the classical second-order linear partial differential equations: Laplace's equation, the heat equation, and the wave equation, together with appropriate boundary or initial conditions. Usually offered in the fall semester.
Prerequisite(s): MATH 343, or consent of the department.

MATH 442. Integral Transf & Asympt. 3 sem. hrs.
Complex variable methods, integral transforms, asymptotic expansions, WKB method, Airy's equation, matched asymptotics, and boundary layers.
Prerequisite(s): MATH 441.

Introduction to mathematical statistics. Topics include bivariate and multivariate probability distributions, functions of random variables, sampling distributions and the central limit theorem, concepts and properties of point estimators, various methods of point estimation, interval estimation, tests of hypotheses and Neyman-Pearson lemma with some applications.
Prerequisite(s): MATH 237 and MATH 355.

MATH 452. Math Stats W/Applictn II. 3 sem. hrs.
Further applications of the Neyman-Pearson Lemma, Likelihood Ratio tests, Chi-square test for goodness of fit, estimation and test of hypotheses for linear statistical models, analysis of variance, analysis of enumerative data, and some topics in nonparametric statistics.
Prerequisite(s): MATH 451.

Introduction to the fundamental concepts and applications of stochastic processes: Markov chains, continuous-time Markov chains, Poisson and renewal processes, and Brownian motion. Applications include queuing theory, communication networks, and finance.
Prerequisite(s): MATH 451.

MATH 460. Intro Differential Geom. 3 sem. hrs.
Introduction to basic classical notions in differential geometry: curvature, torsion, geodesic curves, geodesic parallelism, differential manifold, tangent space, vector field, Lie derivative, Lie algebra, Lie group, exponential map, and representation of a Lie group. Usually offered in the spring semester.
Prerequisite(s): MATH 486.

MATH 465. Intro General Topology. 3 sem. hrs.
Basic notions in topology that can be used in other disciplines in mathematics. Topics include topological spaces, open sets, basis for a topology, continuous functions, separation axioms, compactness, connectedness, product spaces, quotient spaces.
Prerequisite(s): MATH 486.

MATH 466. Intro Algebraic Topology. 3 sem. hrs.
Homotopy, fundamental groups, covering spaces, covering maps, and basic homology theory, including the Eilenberg Steenrod axioms.
Prerequisite(s): MATH 465.

A first course in abstract algebra. Topics include: groups, permutation groups, Cayley's theorem, finite abelian groups, isomorphism theorems, rings, polynomial rings, ideals, integral domains and unique factorization domains. Usually offered in the spring semester.
Prerequisite(s): MATH 237.

MATH 471. Prin Modern Algebra II. 3 sem. hrs.
Introduction to the basic principles of Galois Theory. Topics include rings, polynomial rings, fields, algebraic extensions, normal extensions, and the fundamental theorem of Galois Theory. Usually offered in the fall semester.
Prerequisite(s): MATH 470.

MATH 474. Cryptography. 3 sem. hrs.
Introduction to rapidly growing area of cryptography, an application of algebra, especially number theory. Usually offered in the Fall semester.
Prerequisite(s): MATH 470.

MATH 485. Intro Complex Variables. 3 sem. hrs.
Some basic notions in complex analysis. Topics include analytic functions, complex integration, infinite series, contour integration, and conformal mappings.

MATH 486. Introduction to Real Analysis I. 3 sem. hrs.
Rigorous development of the calculus of real variables. Topics include topology of the real line, sequences, limits, continuity, differentiation.
Prerequisite(s): MATH 237.

MATH 487. Intro to Real Analysis II. 3 sem. hrs.
Riemann integration, introduction to Reimann-Stieltjes integration, series of constants and convergence tests, sequences and series of functions, uniform convergence, power series, Taylor series, and the Weierstrass Approximation Theorem.
Prerequisite(s): MATH 486.

MATH 495. Seminar Directed Reading. 1-3 sem. hr.
Offered as needed.

MATH 499. Undergraduate Research Experience. 1-3 sem. hr.
Independent or collaborative research experience in mathematics.