DEPARTMENT OF MATHEMATICS

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Faculty

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Lecturer: J. P. Kelly, Lenhart, Nailor, Wrayno
Instructor: Carpenter, Tong
Emeritus: Avioli, Bartels, Kostaki-Gailey, Summerville

Mission Statement

As a department within a university that values liberal learning, our mission is to provide a high-quality program that challenges students to appreciate the power, utility and beauty of mathematics. Outstanding teaching is the hallmark of the Department of Mathematics, but in addition, the department maintains a vigorous program of research and service. Programs for mathematics majors and minors prepare students for additional study or for professional careers.

Expected Outcomes

- To instill in students an appreciation for the power and relevance of mathematics as it relates to life,
- To equip students with a solid foundation in theoretical and applied mathematics necessary for advanced study or a professional career,
- To build foundational skills in critical thinking, reasoning, and problem solving,
- To help students develop their individual mathematical interests through internships, independent study, or faculty-student research,
- To provide students with mathematical proficiency to be successful when taking courses in other disciplines such as physics, biology, chemistry, psychology, business, technology, sociology and government.

The Department of Mathematics offers a variety of courses for those who wish to develop general or specific skills in mathematics, to satisfy the mathematics liberal learning foundation, to study mathematics for aesthetic reasons, or to pursue a Bachelor of Arts or Bachelor of Science degree in mathematics or a minor in mathematics.

Historical and philosophical highlights related to the development of mathematics are discussed in various Mathematics major courses. Also, the ability to write computer programs is a prerequisite for MATH 335. Because of the complexity of planning a long-term program for students intending to major or minor in mathematics, especially for those intending to teach mathematics in Virginia secondary schools, students are required to consult with the Department of Mathematics before registering for courses. This applies to both degree and non-degree seeking students.

Calculus Placement

Students intending to register for either MATH 135-Calculus for Business and Social Sciences, MATH 140-Calculus and Analytic Geometry or MATH 148-Accelerated Calculus must have the appropriate prerequisite course (either MATH 110 or MATH 130 for MATH 135; MATH 130 for MATH 140) or receive a passing score on the Calculus Readiness Assessment (CRA). The CRA is administered at Setting Sail and prior to the registration period each semester. Any student intending to major in mathematics, applied physics, computer science, computer engineering, information systems, information science, chemistry, business or economics should take the CRA as soon as possible. The CRA is also offered every semester during the week before registration for the subsequent semester. A student's placement score is good for one academic year. For more information, see the departmental website.

MyLabsPlus

Many 100-level mathematics courses use the *MyLabsPlus* online homework system. After selecting a particular section of a course, students should check the Schedule of Classes to determine whether their section utilizes *MyLabsPlus*. If this is the case, students will need to purchase access to the system and should use the ISBN number provided in the Schedule of Classes to be certain they receive the correct access code.

Overrides

Students seeking an override for a closed course or to waive prerequisites must receive the approval of the Department Chair.

General Requirements for all Math Degrees

All students planning to pursue either the Bachelor of Arts or the Bachelor of Science in mathematics must satisfy the liberal learning curriculum, complete the Major Field Test, and all general requirements for graduation. All courses must be chosen in consultation with an academic adviser. **Students may have no more than two grades below *C*- in courses applied toward the major.**

Bachelor of Arts Degree in Mathematics

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Arts in mathematics must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. MATH 128 or 3 credits in CPSC numbered 125 or higher;
3. MATH 245, 250, 260, 360, 370;
4. Either MATH 451 or MATH 499;
5. Complete 21 credits at the 300-400-level:
   a. Select 12 MATH credits at the 300-400 level (excluding MATH 301, 451); at least 3 credits must be at the 400 level (excluding 451, 490, 499);
   b. Select nine credits at the 300-400 level in MATH (excluding MATH 301W, 308, 451 and 499) **or** in one of the following disciplines: PHYS, CHEM, CPSC, CPEN, ECON, NEUR, BIOL, or BCHM. Courses must be chosen in consultation with the adviser or department chair.

Bachelor of Science Degree in Mathematics

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Science in mathematics must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. CPSC 150/150L;
3. PHYS 201/201L and PHYS 202/202L;
4. MATH 245, 250, 260, 360, 370, 375;
5. MATH 460 or 470;
6. MATH 451 or 499;
7. Complete 15 MATH credits satisfying the following requirements:
   a. Six credits must form a sequence, chosen from the following list of options:
      1) MATH 320 and either MATH 410 or 420;
      2) MATH 335 and MATH 435;
      3) MATH 330 and MATH 345;
      4) MATH 350 and MATH 355;
      5) MATH 380 and MATH 440;
      6) MATH 390 and MATH 400.
   b. Select nine MATH credits at the 300-400 level (excluding MATH 301W, 308, 451).

Bachelor of Science degree, major in Computational and Applied Mathematics

Applied mathematics is the application of mathematics to real-world problems. It is inherently multi-disciplinary given that the applications generally arise in other disciplines. The primary objective of the computational and applied mathematics (CAM) program is to provide a degree where students integrate their interest and ability in mathematics with a complementary interest in an applied discipline. Another important objective of the CAM program is to prepare students for a career or graduate school by combining the CNU liberal learning curriculum with a rigorous mathematics core and a substantive investigation into their chosen application field. The major is completed by choosing one of the following concentrations:

Bachelor of Science degree, major in Computational and Applied Mathematics
Biology and Life Sciences Concentration

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Science in computational and applied mathematics, biology and life sciences concentration, must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. MATH 250, 260, 320, 360, 440;
3. MATH 451 or MATH 499;
4. Select two: CPSC 270, PHYS 341, or any 300-400 level MATH (excluding 301W, 440, 451, 490 and 499). Recommended selections are CPSC 270, MATH 335 or 380;
5. CPSC 150/150L and 250/250L;
6. BIOL 211/211L, 213/213L, 313, and 326;
7. CHEM 121/121L, 122/122L.

Bachelor of Science degree, major in Computational and Applied Mathematics
Computational Chemistry Concentration

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Science in computational and applied mathematics, computational chemistry concentration, must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. MATH 250, 260, 320, 360, 440;
3. PHYS 201/201L and 202/202L;
4. MATH 451 or MATH 499;
5. Select two: CPSC 270, PHYS 341, or any 300-400 level MATH (excluding 301W, 440, 451, 490 and 499). Recommended selections are CPSC 270 and either MATH 335 or 380;
6. CPSC 150/150L and 250/250L;
7. CHEM 121/121L, 122/122L, 321/321L, 341, 342/342L;
8. CHEM 395 Computational Chemistry;

Bachelor of Science degree, major in Computational and Applied Mathematics
Economics Concentration

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Science in computational and applied mathematics, economics concentration, must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. MATH 250, 260, 320, 360, 440;
3. MATH 451 or MATH 499;
4. Select two: CPSC 270, PHYS 341, or any 300-400 level MATH (excluding 301W, 440, 451, 490 and 499). Recommended selections are CPSC 270, and either MATH 335 or 380;
5. CPSC 150/150L and 250/250L;
6. MATH 125 or 435;
7. ECON 201, 202, 485;
8. ACCT 201;
9. FINC 300;
10. Select three credits at the 300-400 level in ECON.
11. One sequence from the following list to satisfy the *University Bachelor of Science Degree Requirement*. No more than three lecture courses may be taken from the same discipline, and no more than two laboratory courses may be taken from the same discipline to satisfy the *University Bachelor of Science Degree Requirement* and the *Investigating the Natural World Area of Inquiry*.
    BIOL 107, 108, 109L
    BIOL 211/211L-212/212L
    BIOL 211/211L-213/213L
    CHEM 103/103L - 104/104L
    CHEM 121/121L - 122/122L
    PHYS 151/151L - 152/152L
    PHYS 201/201L - 202/202L

Bachelor of Science degree, major in Computational and Applied Mathematics
Physics, Dynamics and Engineering Concentration

In addition to the successful completion of the liberal learning curriculum, students seeking a Bachelor of Science in computational and applied mathematics, physics, dynamics and engineering concentration, must successfully complete the following courses:

1. Minimum grade of C- in MATH 140 or 148 and 240;
2. MATH 250, 260, 320, 360, 440;
3. MATH 451 or MATH 499;
4. Select two: CPSC 270, PHYS 341, or any 300-400 level MATH (excluding 301W, 440, 451, 490 and 499). Recommended selections are CPSC 270, and either MATH 335 or 380;
5. CPSC 150/150L and 250/250L;
6. PHYS 201/201L, 202/202L, 303, 340;
7. Select one: CPEN 214, ENGR 211/211L, or 213;
8. Select three credits at the 300-400 level in PHYS or CPEN.

The Minor in Mathematics (19-20 credits)

The minor in mathematics requires successful completion of the following:

1. MATH 140 or 148, with a *C*- or higher;
2. MATH 240 and 260, with a *C*- or higher;
3. MATH 245 or 250, with a *C*- or higher;
4. Six additional MATH credits at the 300- or 400-level.

Teacher Preparation in Mathematics

Those students who wish to become licensed teachers should apply to the five-year Master of Arts in Teaching (M.A.T.) program. Application to the program must be made in spring of the junior year. See the *Graduate Catalog* for application instructions and requirements. Students will earn either a **B.A. or B.S. in mathematics** after the first four years and then take an additional year of studies leading to an M.A.T. degree. The courses and degree requirements for the M.A.T. are found in the graduate catalog. Students accepted into this program must complete one of the following tracks for graduation with the bachelor's degree:

Elementary level (PK-6) Track

Major courses as required for the B.A. in Mathematics.
Support courses required:

- ENGL 123, 223, 310 or 430, and 316;
- CPSC 110;
- GEOG 201; GOVT 101;
- HIST 111 and 121;
- MATH 109 and 125;
- COMM 201 or THEA 230;
- two science courses and one accompanying lab;
- NSCI 310;
- PSYC 208 and 312;
- SOCL 314/ 314L;

Graduate courses* required (senior year):
Select six credits from a), b), or c):

a) MATH 570;
b) PSYC/TCHG 544;
c) MLAN 511, ENGL 530 or 532.

Secondary level (6-12) Track: Math endorsement

Major courses as required for either the B.A. or the B.S. in Mathematics and MATH 335.
Support courses required:

- CPSC 110;
- MATH 125;
- PSYC 207 or 208 and 312;
- SOCL 314/314L;
- COMM 201 or THEA 230 .
- B.S. degree candidates must take PHYS 201- 202 with the accompanying laboratories.

Graduate courses* required (senior year):
Select five-eight credits: MATH 570, 578, 538.
**See the graduate catalog for course descriptions.*

THE CURRICULUM IN MATHEMATICS

MATH 109. Theoretical Foundations of Elementary School Mathematics (3-3-0)
Prerequisite: PSYC 207 or 208 or SOCL 314.
Spring
Strongly recommended for prospective elementary school teachers, this course covers concepts and theories underlying fundamental mathematics. Topics include sets, logic, number sentences, introduction to number theory, number systems, intuitive geometry and measurement.

MATH 110. College Algebra (3-3-0)
Restricted to freshman standing or approval of the chair.
Fall and Spring.
This course is designed for those students who intend to take MATH 130 or MATH 135 and do not have adequate algebra skills for these courses. Topics include real number properties, exponents, polynomial and rational expressions, equations and inequalities, functions, quadratic functions, and logarithms. Students may not receive credit for this course after receiving a grade of *C*- or higher in MATH 130, or any course numbered MATH 135 or higher.

MATH 115. Contemporary Mathematics (3-3-0) LLFM
Prerequisite: through Algebra II in high school.
Fall and Spring.
This course is designed to introduce the student to applications of mathematics, including finance, linear programming (optimization problems), systems of equations, and other topics. Students may not receive credit for this course after receiving a grade of *C*–or higher in any course numbered MATH 250 or higher.

MATH 120. The Saga of Mathematics(3-3-0) LLFM
Prerequisite: through Algebra II in high school.
Spring.
An introduction to the history of mathematics, concentrating on the period from the Greeks through the 19th century. This course shows the history and development of mathematics as a vital and integral part of the history of civilization, including the history of numbers and numerals, computation, geometry, algebra, trigonometry, calculus and modern mathematics.

MATH 123. Mathematical Excursions (3-3-0) LLFM
Prerequisite: through Algebra II in high school.
This course is designed to introduce students to applications of mathematics, including voting methods, routing problems, network problems, and spiral growth in nature. The major emphasis is on the process of taking a real-world problem, converting this to a mathematical model, and then solving the problem. Students may not receive credit for this course after receiving a grade of *C*– or higher in any course numbered MATH 250 or higher.

MATH 125. Elementary Statistics (3-3-0) LLFM
Prerequisite: through Algebra II in high school.
Fall and Spring.
This course is a general survey of descriptive and inferential statistics. Topics include descriptive analysis of univariate and bivariate data, probability, standard distributions, sampling, estimation, hypothesis testing and linear regression. Students may not receive credit for this course after receiving a grade of *C*– or higher in MATH 435.

MATH 127. Elementary Cryptography (3-3-0) LLFM
Fall and Spring.
This course examines elementary cryptographic methods, ranging from early Caesar cipher to modern day RSA encryption. Modular arithmetic and how it can be used for cryptographic methods is studied. Cryptanalysis of the resulting methods will also be studied. No previous experience with cryptography or the underlying mathematics is assumed. Students may not receive credit for this course after receiving a grade of *C*– or higher in CPSC 428.

MATH 128. Introduction to Mathematical Programming (3-3-0) LLFM
Fall and Spring.
This course will introduce the student to mathematical programming, in which researchers use a high-level programming language (e.g., Mathematica) to model, analyze, visualize and calculate numeric, geometric and symbolic data. In addition, it is designed for the student to take early so that he or she will have a powerful tool to use in subsequent courses in many disciplines. Specific topics include programming, logic, visualization, sets, sums, products, loops, substitution, patterns, and matrices.

MATH 130. Precalculus (3-3-0) LLFM
Prerequisite: through Algebra II in high school.
Fall and Spring.
Designed for the student planning to take calculus, MATH 140, but who has insufficient knowledge of analytic geometry, trigonometry, and functions. Topics include real numbers, inequalities, analytic geometry, linear and quadratic functions, polynomials and rational functions, trigonometry, and exponential and logarithmic functions. Students may not receive credit for this course after receiving a grade of *C*– or higher in any course numbered MATH 250 or higher.

MATH 131. Mathematics for the Life Sciences (3-3-0) LLFM
Fall and Spring.
This course is intended for biology majors to satisfy the second half of the Mathematical Literacy requirement, as well as anyone with an interest in the life sciences. Topics will include: model building and parameter estimation through regression analysis of life tables and analysis of matrix population models. Concepts of growth rate, half-

life and doubling time, elasticity, life expectancy, stable age distribution and reproductive value will be discussed. No specialized knowledge of biology is required.

MATH 135. Calculus for Business and Social Sciences (3-3-0) LLFM
Prerequisite: A minimum grade of C- in MATH 110 or 130 or an acceptable score on the Calculus Readiness Assessment.
Fall and Spring.
An introduction to the calculus of functions arising in business and the social sciences. Exponential and logarithmic functions, differentiation, and integration. Modeling and applications will be stressed. Students may not receive credit for this course after receiving a grade of *C–* or higher in any course numbered MATH 250 or higher.

MATH 140. Calculus and Analytic Geometry (4-4-1) LLFM
Prerequisite: A minimum grade of C- in MATH 130 or an acceptable score on the Calculus Readiness Assessment.
Fall and Spring.
An introduction to the calculus of elementary functions, continuity, derivatives, methods of differentiation, the Mean Value Theorem, curve sketching, applications of the derivative, the definite integral, the Fundamental Theorems of Calculus, indefinite integrals, and logarithmic and exponential functions. The software package *Mathematica* will be used.

MATH 148. Accelerated Calculus (3-3-0) LLFM
Prerequisite: An acceptable score on the Calculus Readiness Assessment.
Fall and Spring.
Accelerated version of MATH 140 for students who have been exposed to calculus in high school Students cannot receive credit for MATH 148 after receiving a grade of C- or higher in MATH 140, or if grade of *C–* or higher has been earned in any course numbered 250 or higher or their equivalent.

MATH 195. Special Topics (3-3-0)
As needed.
Topics vary, determined by the special interests and needs of students and the expertise of faculty.

MATH 235. Applied Matrix Techniques (3-3-0)
Prerequisite: MATH 135 or MATH 140 or 148, CPSC 125 or 150/150L.
Fall and as needed in Spring.
Topics in applied linear algebra such as systems of linear equations, Gaussian elimination, matrix algebra, determinants, Cramer's rule, eigenvalues and vectors. Also applications in some of these areas: linear programming, game theory, Markov chains, input/output models, graph theory, and genetics. A computer project may be required.

MATH 240. Intermediate Calculus (4-4-0)
Prerequisite: A minimum grade of C- in either MATH 140 or 148.
Fall and Spring.
Techniques of integration, L'Hospital's Rule, application of integration, approximations, Taylor's Theorem, sequences and limits, series of numbers and functions, power series, and Taylor series. The software package *Mathematica* will be used.

MATH 245. Proofs and Discrete Mathematics (3-3-0) [Formerly MATH 310, equivalent]
Pre or corequisite: MATH 240.
Topics are presented so as to develop facility with methods of proof and mathematical argument. Topics will include logic, sets, binary relations, functions, binary operations, elementary number theory, number bases, mathematical induction, recursive definitions and algorithms, and other topics at the discretion of the instructor. Students should take MATH 240 concurrently or prior to MATH 245.

MATH 250. Multivariable Calculus (3-3-0)
Prerequisite: A minimum grade of C- in MATH 240.
Fall and Spring.
An introduction to the calculus of real-valued functions of more than one variable. The geometry of three-space, vector-valued functions, partial and directional derivatives, multiple and iterated integrals, and applications. The software package *Mathematica* will be used.

MATH 260. Linear Algebra (3-3-0)
Prerequisite: MATH 240.
Fall and Spring.
Systems of linear equations, matrix operations, determinants, vectors and vector spaces, independence, bases and dimension, coordinates, linear transformations and matrices, eigenvalues and eigenvectors.

MATH 295. Special Topics (credits vary 1-3)
Prerequisite: announced at the appropriate time.
As needed.
Topics vary, determined by the special interests and needs of students and the expertise of faculty. Courses can range from one-credit laboratories to three-credit courses on topics of immediate importance.

MATH 301. WI: Writing in Mathematics I (1-1-0)
Prerequisite: ENGL 223; MATH 240 and junior standing.
Fall and Spring.
Course will consist of several individual writing assignments and a possible group project designed to help students: investigate selected mathematics concepts/topics by using what they already know and expanding on it; gain experience in interpreting data and/or research such as reporting on selected articles from the MAA Mathematics Magazine and the JRME; practice the type of writing associated with mathematics. Partially satisfies the writing intensive requirement.

MATH 320. Ordinary Differential Equations (3-3-0)
Prerequisite: A minimum grade of C - in MATH 240.
Fall and Spring.
A treatment of ordinary differential equations and their applications. Topics will include techniques for the qualitative analysis of autonomous equations and methods for determining analytical solutions for certain classes of equations.

MATH 330. Graph Theory and Combinatorics (3-3-0)
Prerequisite: A minimum grade of C- in MATH 245.
Spring, odd numbered years.
This course will emphasize the basic methods of enumeration, up to generating functions. It also will strive to apply learned counting methods to the central objects of combinatorics, such as permutations, graphs, and hypergraphs. If time permits, this course will cover some special topics that will provide the students with a closer view of research problems.

MATH 335. Applied Probability (3-3-0)
Prerequisite: A minimum C- in MATH 240, a minimum C- in at least one of MATH 128, CPSC 125, 130L or 150
Fall.
Elementary probability theory including combinatorics, distributions of random variables, conditional probability, and moment generating functions. An introduction to stochastic processes including such topics as Markov chains, random walks, and queuing theory. Case studies. Computer projects may be required.

MATH 345. Number Theory (3-3-0)
Prerequisite: A minimum grade of C- in MATH 245.
Spring, even numbered years.
Topics include prime numbers, linear Diophantine equations, congruencies, theorems of Fermat, Wilson, and Euler, and numbers in other bases.

MATH 350. Vector Calculus (3-3-0)
Prerequisite: A minimum grade of C- in MATH 250.
Spring, even numbered years.
An introductory course in differential and integral vector calculus. Topics include vector operations, gradients, divergence, curl, line integrals, Green's Theorem, Stokes' Theorem, Divergence Theorem, and applications.

MATH 355. Complex Variables (3-3-0)
Prerequisite: A minimum grade of C- in MATH 250.
Spring, odd numbered years.
Introduction to the calculus of complex variables and its application to applied mathematics, physics and engineering. Topics include analytic functions, Cauchy-Reimann equations, residues and poles, and conformal mapping.

MATH 360. Real Analysis I (3-3-0)
Prerequisite: A minimum grade of C- in MATH 250 and 260.
Fall and Spring
A first course in real analysis covering various topics including point-set topology, continuity, differentiability, the Riemann integral, sequences of functions, series of functions, Taylor and Fourier series, uniform continuity and uniform convergence.

MATH 370. Modern Algebra I (3-3-0)
Prerequisite: A minimum grade of C- in MATH 245 and 260.
Fall.
This is an introduction to binary operations and algebraic structures. Concentrating on group theory, topics include abstract groups, abelian groups, permutation groups, homomorphisms and quotient groups. This is a proof-based course, stressing both concrete and theoretical concepts in algebra.

MATH 375. Linear Algebra and its Applications (3-3-0)
Prerequisite: A minimum grade of C- in MATH 260.
This course is a continuation of Math 260. Math 245 with a minimum grade of C- is recommended. While emphasizing theory, this course will include appropriate applications. Starting with a systematic study of general vector spaces over **R** and **C**, linear transformations and operators, the course progresses to such topics as bilinear forms and inner product spaces, the Gram-Schmidt orthogonalization process, linear functionals, and dual spaces. Eigentheory over **R** and **C** is studied. Applications such as QR-decompositions, singular value decomposition, least squares and regression, Fourier series, and the Jordan canonical form will be covered as time allows.

MATH 380. Numerical Analysis I (3-3-0)
Prerequisite: A minimum grade of C- in MATH 240 and 260.
Fall, odd numbered years.
A survey of numerical methods for scientific and engineering problems. Topics will include: rootfinding techniques, polynomial and spline interpolation, numerical differentiation and integration and the numerical solution of initial value problems for ordinary differential equations. Consideration will be given to theoretical concepts and to efficient computation procedure. Computer projects will be required.

MATH 390. Mathematical Methods of Operations Research I (3-3-0)
Prerequisite: A minimum grade of C- in MATH 240 and 260.
Fall, even numbered years.
A study of the nature, scope, applications, and theoretical basis of operations research. The simplex algorithm, theoretical and computational aspects, duality theory and its relationship to game theory, dynamic programming, case studies. Computer projects may be required.

MATH 395. Special Topics (credits vary 1-3)
Prerequisite: as announced.
As needed.
Topics vary, determined by the special interests and needs of students and the expertise of faculty.

MATH 400. Mathematical Methods of Operations Research II (3-3-0)
Prerequisite: MATH 390.
Spring, odd numbered years.
Mathematical theory and techniques of network algorithms, integer programming, inventory control, sequencing and scheduling, and computational complexity of algorithms. Case studies. Computer projects may be required.

MATH 410. Advanced Ordinary Differential Equations (3-3-0)
Prerequisite: MATH 320.
Fall, even numbered years.
A second course in ordinary differential equations. Topics will be selected from: series solutions near singular points, systems of first-order linear equations, non-linear differential equations, autonomous systems, phase plane and stability, Sturm-Liouville theory, numerical methods, and existence theory.

MATH 420. Partial Differential Equations (3-3-0)
Prerequisite: MATH 320 and 360.
Fall, odd numbered years.
Discussion of methods used in solving problems arising from continuous mathematical models. An introduction to partial differential equations. Additional topics may include: Sturm-Liouville Theory and qualitative theory of ordinary differential equations, transform methods, Green's functions, delay differential equations, special functions, and numerical methods.

MATH 435. Mathematical Statistics (3-3-0)
Prerequisite: MATH 335.
Spring, even numbered years.
A study of the nature, scope, and theoretical basis of methods of estimation, hypothesis testing, and statistical decision making. Descriptive statistics, quality of estimators and best tests, techniques of estimation and hypothesis testing, and regression analysis. Additional topics such as analysis of variance, non-parametric procedures, sampling techniques and MINITAB. Computer projects may be required.

MATH 440. Mathematical Modeling (3-3-0)
Prerequisite: MATH 320 and 360.
Spring.
Modeling and solution of some problems that arise in the sciences. Emphasis on development of appropriate models and an awareness of their domain of applicability.

MATH 451. Independent Learning Experience (1-1-0)
Prerequisite: either MATH 360 or 370.
Spring.
This course is designed to introduce students to techniques for effectively communicating mathematical reasoning and content and to provide students with the opportunity to demonstrate their ability to study some area of mathematics beyond what the student sees in the standard mathematics curriculum under faculty advisement. Students will perform independent reading of multiple sources and prepare small written summaries of each reading and will communicate their findings both in the form of an oral presentation and a written report.

MATH 460. Real Analysis II (3-3-0)
Prerequisite: MATH 360.
Spring, odd numbered years.
This is a continuation of Math 360. Topics will include metric spaces, continuous functions on metric spaces, uniform convergence, power series, Fourier series, multi-variable differential calculus along with Lebesgue measure theory and Lebesgue integration.

MATH 470. Modern Algebra II (3-3-0)
Prerequisite: MATH 370.
Spring, even numbered years.
This course is a continuation of Math 370. Topics will include rings, fields, field extensions, and polynomial rings over fields. Additional topics may include Galois theory, unique factorization, principal ideal, Euclidean domains, and non-commutative examples. This is a proof-based course, stressing both concrete and theoretical concepts in algebra.

MATH 490. Internship in Mathematics (Credits vary 1-3)
Prerequisite: CPSC 150/150L, MATH 360 and at least nine semester hours of additional MATH coursework at the 300-400 level: minimum 3.00 GPA in all 300-400 level mathematics courses completed; approval of the departmental director of internships. Restricted to mathematics majors.
Credit varies from one to three semester hours, with 40 clock hours (60 minute hours) of scheduled, on-site time required for each semester hour of credit earned. This course may be taken repeatedly for credit until a maximum of three semester hours of credit has been earned. A project-based experience in a private, governmental, or military organization which permits the intern to apply his or her formal education to a project of mathematical substance and to gain appropriate experience as an apprentice in a mathematically-related employment environment. **This course is graded *Pass/fail***. Course may be repeated for a maximum of three credits.

MATH 495. Special Topics (credits vary 1-3)
Prerequisite: as announced.
As needed.
Topics vary, determined by the special interests and needs of students and the expertise of faculty.

MATH 499. Independent Research (credits vary 1-3)
Prerequisite: junior or standing and permission of the instructor and department chair.
As needed.
Individual research on an approved subject may be taken for one to three credits.