MATHEMATICAL SCIENCES, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN BIOMATHEMATICS

The curriculum in mathematical sciences promotes understanding of the mathematical sciences and their structures, uses and relationships to other disciplines. To this end, the scholarly growth of the faculty and students in the mathematical sciences is nurtured through study, research and a high standard of teaching. The curriculum provides a sound foundation for the student seeking to enter a career with a technological orientation or for the student who wishes to pursue graduate study in applied mathematics, biomathematics, mathematics, operations research, statistics, teaching mathematics in secondary schools or related fields.

A Bachelor of Science is offered jointly by the Department of Mathematics and Applied Mathematics and the Department of Statistical Sciences and Operations Research. In the Department of Mathematics and Applied Mathematics, students pursuing the Bachelor of Science in Mathematical Sciences can choose a concentration of biomathematics, which focuses on the overlap between mathematics and the disciplines of biology and medicine. This concentration covers the mathematical methods of modeling and analysis of phenomena in the life sciences.

Learning outcomes
Upon completing this program, students will know and know how to do the following:

• Pursue goals and careers in education and industry
• Think creatively
• Analyze and write mathematical arguments
• Read and interpret literature
• Use technology in problem-solving and experimentation

Special requirements
The B.S. in Mathematical Sciences requires a minimum of 120 credits. Along with the general education requirements of the College of Humanities and Sciences and the undergraduate degree requirements, students are required to take core courses and fulfill specific requirements for the degree.

Based on the results of the Mathematics Placement Test, students may be required to take MATH 151. No more than one course in mathematics (MATH) at the 100 level can count for the general requirements toward the degree. Credit for 100-level mathematical sciences courses cannot be applied toward the mathematical sciences courses required for the major in mathematical sciences.

Double major
Students who meet the requirements for two of the concentrations within the mathematical sciences curriculum can receive a double major. To initiate a double major, students must obtain the appropriate form from the Office of Records and Registration.

Second baccalaureate degree
For students possessing a bachelor's degree and wishing to gain undergraduate preparation in an area of mathematical sciences, second baccalaureate degrees are offered through the department. For detailed information about these programs, refer to the "Academic regulations and general degree requirement" section of this bulletin.

Degree requirements for Mathematical Sciences, Bachelor of Science (B.S.) with a concentration in biomathematics

General education requirements

<table>
<thead>
<tr>
<th>University Core Education Curriculum (minimum 21 credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIV 111 Play course video for Focused Inquiry I</td>
</tr>
<tr>
<td>UNIV 112 Play course video for Focused Inquiry II</td>
</tr>
<tr>
<td>UNIV 200 Inquiry and the Craft of Argument</td>
</tr>
<tr>
<td>Approved humanities/fine arts</td>
</tr>
<tr>
<td>Approved natural/physical sciences</td>
</tr>
<tr>
<td>Approved quantitative literacy</td>
</tr>
<tr>
<td>Approved social/behavioral sciences</td>
</tr>
<tr>
<td>Total Hours</td>
</tr>
</tbody>
</table>

Additional College of Humanities and Sciences requirements (11-23 credits)

| HUMS 202 Choices in a Consumer Society                   | 1 |
| Approved H&S diverse and global communities              | 3 |
| Approved H&S human, social and political behavior (fulfills University Core social/behavioral sciences) | |
| Approved H&S literature and civilization (fulfills University Core humanities/fine arts) |
| Approved H&S science and technology (fulfills University Core natural/physical sciences) |
| Approved H&S general education electives                | 6-8 |
| Experiential fine arts                                  | 1-3 |
| Foreign language through the 102 level (by course or placement) | 0-8 |
| Total Hours                                              | 11-23 |

1 Course offered by the School of the Arts

Collateral requirements

Select one of the following sequences:

<table>
<thead>
<tr>
<th>Sequence 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 151 &amp; BIOZ 151 Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sequence 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 152 &amp; BIOZ 152 Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II</td>
</tr>
</tbody>
</table>

Sequence 2
What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

### Freshman year

#### Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 200 Calculus with Analytic Geometry</td>
<td>4</td>
</tr>
<tr>
<td>MATH 201 Calculus with Analytic Geometry</td>
<td>4</td>
</tr>
<tr>
<td>STAT 212 Concepts of Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Foreign language 101</td>
<td>4</td>
</tr>
<tr>
<td>Term Hours:</td>
<td>14-15</td>
</tr>
</tbody>
</table>

#### Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 255 Introduction to Computational Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>or CMSC 245 Introduction to Programming Using C++</td>
<td>3</td>
</tr>
<tr>
<td>or EGRE 245 Engineering Programming</td>
<td>3</td>
</tr>
<tr>
<td>MATH 300 Introduction to Mathematical Reasoning</td>
<td>3</td>
</tr>
<tr>
<td>MATH 301 Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 307 Multivariate Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 310 Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 380 Introduction to Mathematical Biology</td>
<td>4</td>
</tr>
<tr>
<td>MATH 407 Advanced Calculus</td>
<td>3</td>
</tr>
<tr>
<td>MATH 490 Mathematical Expositions (capstone)</td>
<td>3</td>
</tr>
<tr>
<td>Foreign language 102</td>
<td>4</td>
</tr>
<tr>
<td>Term Hours:</td>
<td>17</td>
</tr>
</tbody>
</table>

### Sophomore year

#### Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 380 Introduction to Mathematical Biology</td>
<td>4</td>
</tr>
<tr>
<td>MATH 300 Introduction to Mathematical Reasoning</td>
<td>3</td>
</tr>
<tr>
<td>MATH 307 Multivariate Calculus</td>
<td>4</td>
</tr>
<tr>
<td>STAT 212 Concepts of Statistics (fulfills University Core quantitative literacy)</td>
<td>3</td>
</tr>
<tr>
<td>Foreign language 102</td>
<td>4</td>
</tr>
<tr>
<td>Term Hours:</td>
<td>17</td>
</tr>
</tbody>
</table>

#### Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 301 Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 310 Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Approved H&amp;S literature and civilization</td>
<td>3</td>
</tr>
<tr>
<td>Approved H&amp;S science and technology</td>
<td>3-4</td>
</tr>
<tr>
<td>Foreign language 102</td>
<td>4</td>
</tr>
<tr>
<td>Term Hours:</td>
<td>16-17</td>
</tr>
</tbody>
</table>

### Junior year

#### Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 380 Introduction to Mathematical Biology</td>
<td>4</td>
</tr>
<tr>
<td>Approved H&amp;S General Education elective</td>
<td>3-4</td>
</tr>
<tr>
<td>Experiential fine arts</td>
<td>1-3</td>
</tr>
<tr>
<td>Natural science sequence (Select one of the following.)</td>
<td>4-5</td>
</tr>
<tr>
<td>BIOL 151 Introduction to Biological Sciences I &amp; BIOZ 151 and Introduction to Biological Science Laboratory I</td>
<td>-</td>
</tr>
<tr>
<td>CHEM 101 General Chemistry I &amp; CHEZ 101 and General Chemistry Laboratory I</td>
<td>-</td>
</tr>
<tr>
<td>PHYS 201 General Physics I</td>
<td>-</td>
</tr>
</tbody>
</table>

### Open electives

Select 11-32 open elective credits

### Total minimum requirement 120 credits
PHYS 207  University Physics I  4-Hours

Spring semester

MATH 480  Methods of Applied Mathematics for the Life Sciences: Discrete  3-Hours
or MATH 481  or Methods of Applied Mathematics for the Life Sciences: ODE  3-Hours
or MATH 482  or Methods of Applied Mathematics for the Life Sciences: PDE  3-Hours

Biomathematics concentration elective (upper-level)  3-Hours

Natural science sequence (Select one of the following with appropriate matching course.)

BIOI 152  Introduction to Biological Sciences II  4-Hours
& BIOI 152  and Introduction to Biological Science Laboratory II  4-Hours

CHEM 102  General Chemistry II  4-Hours
& CHEZ 102  and General Chemistry Laboratory II  4-Hours

PHYS 202  General Physics II  4-Hours

PHYS 208  University Physics II  4-Hours

Open electives  6-Hours

Term Hours:  12-16

Senior year

Fall semester

MATH 407  Advanced Calculus  3-Hours

MATH 480  Methods of Applied Mathematics for the Life Sciences: Discrete  3-Hours
or MATH 481  or Methods of Applied Mathematics for the Life Sciences: ODE  3-Hours
or MATH 482  or Methods of Applied Mathematics for the Life Sciences: PDE  3-Hours

MATH 585  Biomathematics Seminar  1-Hours

Natural sciences elective  3-5

Open electives  6-Hours

Term Hours:  16-17

Spring semester

MATH 490  Mathematical Expositions  3-Hours

MATH 585  Biomathematics Seminar  1-Hours

Biomathematics concentration elective (upper-level)  3-Hours

Open electives  8-Hours

Term Hours:  15-Hours

Total Hours:  120-130

1 Not from general education science and technology list and different science than chosen for sequence.

Students registering for:

CMSC 255  Introduction to Programming  4-Hours

MATH 131  Introduction to Contemporary Mathematics  3-Hours

MATH 141  Algebra with Applications  3-Hours

MATH 151  Precalculus Mathematics  4-Hours

MATH 200  Calculus with Analytic Geometry  4-Hours

MATH 211  Mathematical Structures  3-Hours

MATH 300  Introduction to Mathematical Reasoning  3-Hours

must place into these courses either from receiving VCU credit for stated prerequisite courses (for instance, MATH 151 is a stated prerequisite course for MATH 200) or from a satisfactory score (within a 39-month period immediately preceding the beginning of the course) on the VCU Mathematics Placement Test.

MATH 001. Elementary Algebra. 0 Hours.

Semester course; 3 lecture or 3 laboratory/tutorial hours. No credit. Prerequisite: permission of the department chair. The purpose of this course is to provide laboratory and tutorial instruction for those seeking remediation or review of high school algebra. Topics include basic properties of real numbers, operations with algebraic expressions, solution of equations and inequalities, exponents and radicals, introduction to functions and graphing.

MATH 121. Perspective Geometry. 1 Hour.

Short course (5 weeks); 3 lecture hours. 1 credit. Students will examine ways in which Renaissance artists who developed linear perspective in geometry in order to paint scenes realistically influenced the development of mathematics and geometry. Topics covered will include the foundations of projective geometry. Pascal's mystic hexagram, Brianchon's Theorem and duality. A need for higher mathematics will also be introduced and explained. MATH 121-122-123 fulfills the math requirement for art students. The sequence can be taken in any order.

MATH 122. Tessellations. 1 Hour.

Short course (5 weeks); 3 lecture hours. 1 credit. Students will examine ways in which mathematics is rooted in both natural philosophy and art by examining tiling theory. Course topics include Penrose tilings, symmetries and various other tessellations. MATH 121-122-123 fulfills the math requirement for art students. The sequence can be taken in any order.

MATH 123. Visualization. 1 Hour.

Short course (5 weeks); 3 lecture hours. 1 credit. Students will examine ways in which mathematics has been visualized artistically and will develop their own way to express a mathematical idea. Topics covered will include fractals, knots, minimal surfaces, non-Euclidean geometry and the fourth dimension. MATH 121-122-123 fulfills the math requirement for art students. The sequence can be taken in any order.

MATH 131. Introduction to Contemporary Mathematics. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. An exception to this policy is made in the case where the stated alternative prerequisite course has been completed at VCU. Topics include optimization problems, data handling, growth and symmetry, and mathematics with applications in areas of social choice. Major emphasis is on the process of taking a real-world situation, converting the situation to an abstract modeling problem, solving the problem and applying what is learned to the original situation. Does not serve as a prerequisite for MATH 151 or other advanced mathematical sciences courses.
MATH 141. Algebra with Applications. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: one year of high school algebra and satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. An exception to this policy is made in the case where the stated alternative prerequisite course has been completed at VCU. Topics include sets, functions, exponents, logarithms, matrix algebra, systems of linear equations, inequalities, binomial theorems, sequences, series, complex numbers and linear programming.

MATH 151. Precalculus Mathematics. 4 Hours.
Semester course; 3 lecture and 1 mathematics laboratory/recitation hours. 4 credits. Prerequisite: MATH 141 or satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. An exception to this policy is made in the case where the stated alternative prerequisite course has been completed at VCU. Concepts and applications of algebra and trigonometry. Topics include graphics, transformations and inverses of functions, linear, exponential, logarithmic, power, polynomial, rational and trigonometric functions.

MATH 191. Topics in Mathematics. 1-3 Hours.
Semester course; 1-3 credits. May be repeated for credit. A study of selected topics in mathematics. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

MATH 200. Calculus with Analytic Geometry. 4 Hours.
Continuous courses; 4 lecture hours. 4-4 credits. Prerequisite for MATH 200: MATH 151 or satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. Prerequisite for MATH 201: completion of MATH 200. Limits, continuity, derivatives, differentials, antiderivatives and definite integrals. Applications of differentiation and integration. Selected topics in analytic geometry. Infinite series.

MATH 201. Calculus with Analytic Geometry. 4 Hours.
Continuous courses; 4 lecture hours. 4-4 credits. Prerequisite for MATH 200: MATH 151 or satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. Prerequisite for MATH 201: completion of MATH 200. Limits, continuity, derivatives, differentials, antiderivatives and definite integrals. Applications of differentiation and integration. Selected topics in analytic geometry. Infinite series.

MATH 211. Mathematical Structures. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: calculus-level placement on the VCU Mathematics Placement Test within the one-year period immediately preceding enrollment in the course or MATH 151, MATH 200, MATH 201 or MGMT 212. An alternative prerequisite course may be approved at the discretion of the academic adviser. An introduction to mathematical logic and set theory, including applications in Boolean algebras and graph theory.

MATH 230. Mathematics in Civilization. 3 Hours.
Semester course; 3 lecture hours. 3 credits. For Honors College students only. The growth, development and far-reaching applications of trigonometry, navigation, cartography, logarithms and algebra through ancient, medieval, post-Renaissance and modern times are explored. Will include methods to solve mathematical problems using various historical procedures and will involve collaboration through group projects.

MATH 255. Introduction to Computational Mathematics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201. (A core course for mathematics/applied mathematics majors.) An introduction to computer algebra systems (CAS) and their use in mathematical, scientific and engineering investigations/computations. Introductory mathematical computer programming using a CAS, including implementation of problem-specific algorithms.

MATH 291. Topics in Mathematics. 1-3 Hours.
Semester course; 1-3 credits. May be repeated for credit. A study of selected topics in mathematics. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

MATH 300. Introduction to Mathematical Reasoning. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201. (A core course for mathematics/applied mathematics majors.) An introduction to basic concepts of mathematical reasoning and the writing of proofs in an elementary setting. Direct, indirect and induction proofs. Illustrations of the concepts include basic proofs from mathematical logic, elementary set theory, elementary number theory, number systems, foundations of calculus, relations, equivalence relations, functions and counting with emphasis on combinatorial proofs.

MATH 301. Differential Equations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201. Solutions of ordinary differential equations of first order. Solutions of higher order linear differential equations with constant coefficients and variable coefficients by the methods of undetermined coefficients and variation of parameters, solutions by Laplace transforms and applications.

MATH 302. Numerical Calculus. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 255 (or knowledge of a programming language/mathematical software package) and MATH 201, or permission of the instructor. An introduction to numerical algorithms for solving systems of linear equations, finding zeros, numerical differentiation and definite integration, optimization.

MATH 303. Investigations in Geometry. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: MATH 201. Restricted to students majoring in the liberal studies for early and elementary education in the Bachelor of Interdisciplinary Studies program. A study of topics in Euclidean geometry to include congruence, similarity, measurement, coordinate geometry, symmetry and transformation in both two and three dimensions. These topics will be investigated using manipulatives and computer software.

MATH 305. Elementary Number Theory. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 300. Divisibility, congruences, Euler phi-function, Fermat’s Theorem, primitive roots, Diophantine equations.

MATH 307. Multivariate Calculus. 4 Hours.
Semester course; 4 lecture hours. 4 credits. Prerequisite: MATH 201. The calculus of vector-valued functions and of functions of more than one variable. Partial derivatives, multiple integrals, line integrals, surface integrals and curvilinear coordinates. Lagrange multipliers; theorems of Green, Gauss and Stokes. Applications.

MATH 310. Linear Algebra. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201. Systems of linear equations, vector spaces, linear dependence, bases, dimensions, linear mappings, matrices, determinants, quadratic forms, orthogonal reduction to diagonal form, eigenvalues and geometric applications.
Mathematical Sciences, Bachelor of Science (B.S.) with a concentration in biomathematics

MATH 350. Introductory Combinatorics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201 with a minimum grade of C. An introduction to basic combinatorial concepts such as combinations, permutations, binomial coefficients, Fibonacci numbers and Pascal’s triangle; basic theorems such as the pigeonhole principle and Newton’s binomial theorem; algorithms such as bubble sort and quicksort; and discussion of basic applications such as chessboard problems, combinatorial games, magic squares and Latin squares.

MATH 351. Applied Abstract Algebra. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 300. A survey of several areas in applied abstract algebra which have applications in computer science such as groups, codes, matrix algebra, finite fields and advanced graph theory.

MATH 353. Experimental Mathematics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201 with a minimum grade of C. An introduction to a mathematical computing package, computer manipulation of lists and sets, and symbolic computing. Numerical computation will be used to investigate mathematical objects, such as integers, prime numbers, graphs, matrices and to identify properties and patterns among these objects. Random methods will be used to explore properties and patterns in long sequences and large collections.

MATH 356. Graphs and Algorithms. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201 with a minimum grade of C. An introduction to basic graph theoretic concepts such as trees, colorings and matchings; basic theorems such as the handshaking lemma and the Gallai identities; algorithms such as Dijkstra’s and Kruskal’s; and discussion of famous open problems such as finding shortest tours for a traveling salesman.

MATH 361. Numbers and Operations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: TEDU 101 and either MATH 131 or satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course. Ways of representing numbers, relationships between numbers, number systems, the meanings of operations and how they relate to one another, and computation within the number systems as a foundation for algebra. Structured observations and tutoring of elementary-level students. Restricted to students majoring in the liberal studies concentration for early and elementary education in the Bachelor of Interdisciplinary Studies program.

MATH 362. Algebra and Functions. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 361. Topics include algebraic concepts, linear, quadratic, exponential, logarithmic, trigonometric functions including graphical modeling of physical phenomena. Attention will be given to the use of graphing technology, the transition from arithmetic to algebra, working with quantitative change, and the description and prediction of change. Structured observations and tutoring of elementary-level students. Restricted to B.I.S. students in the liberal studies for early and elementary education concentration.

MATH 380. Introduction to Mathematical Biology. 4 Hours.
Semester course; 3 lecture and 2 laboratory hours. 4 credits Prerequisites: MATH 200 and BIOL 151, or permission of instructor. An introduction to mathematical biology. Various mathematical modeling tools will be covered and implemented in a range of biological areas. Additionally, the collaborative research process will be presented and discussed. Crosslisted as: BINFO 380/BIOL 380.

MATH 391. Topics in Mathematics. 1-3 Hours.
Semester course; 1-3 credits. May be repeated for credit. A study of selected topics in mathematics. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

MATH 401. Introduction to Abstract Algebra. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300 and MATH 310, each with a minimum grade of C. An introduction to groups, rings and fields from an axiomatic point of view. Coset decomposition and basic morphisms.

MATH 404. Algebraic Structures and Functions. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300 and MATH 310, each with a minimum grade of C; one additional mathematical sciences course; and permission of instructor. Semigroups, groups, rings, integral domains and fields. Exponential, logarithmic and trigonometric functions. Graphing in parametric and polar coordinates. Arithmetic and geometric sequences and series.

MATH 407. Advanced Calculus. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 300. Theoretical aspects of calculus. Topics include properties of real numbers, countable and uncountable sets, sequences and series, limits, continuity, derivatives, and Riemann integration.

MATH 409. General Topology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 407 with a minimum grade of C. Foundations and fundamental concepts of point-set topology. Topological spaces, continuity, convergence, connected sets, compactness, product spaces, quotient spaces, function spaces, separation properties.

MATH 415. Numerical Methods. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 255, MATH 301 and MATH 310, each with a minimum grade of C. Numerical methods for interpolation, solving systems of linear equations and initial value problems (ordinary differential equations) and the exploration of computational error.

MATH 427. Excursions in Analysis: Real. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307, MATH 310 and MATH 407. May be repeated once for credit with a different emphasis and permission of the instructor. Intensive study of ideas and applications from real analysis.

MATH 428. Excursions in Analysis: Complex. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307, MATH 310 and MATH 407. May be repeated once for credit with a different emphasis and permission of the instructor. Intensive study of ideas and applications from complex analysis.

MATH 429. Excursions in Analysis: Applied. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307, MATH 310, MATH 310 and MATH 407. May be repeated once for credit with a different emphasis and permission of the instructor. Intensive study of ideas and applications from applied analysis.

MATH 430. The History of Mathematics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300, MATH 307, MATH 310, and either MATH 301 or OPER 327, all with a minimum grade of C. Surveys major trends in the development of mathematics from ancient times through the 19th century and considers the cultural and social contexts of mathematical activity.
MATH 431. Expositions in Modern Mathematics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300,
MATH 307, MATH 310, and either MATH 301 or OPER 327, all with
a minimum grade of C. Descriptively studies several major ideas relevant
to present-day mathematics, such as the advent of pure abstraction,
difficulties in the logical foundations of mathematics, the impact
of mathematics and statistics in the 20th century and the computer
revolution.

MATH 432. Ordinary Differential Equations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300,
MATH 301, MATH 307 and MATH 310, each with a minimum grade of
C. Existence and uniqueness of solutions, linearization and stability
analysis, Lyapunov stability theory, periodic solutions, and bifurcations.
Applications and simulations are emphasized.

MATH 433. Partial Differential Equations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300,
MATH 301, MATH 307 and MATH 310, each with a minimum grade of
C. Parabolic (heat), hyperbolic (wave) and elliptic (steady-state)
partial differential equations are studied. Solution techniques such as
separation of variables, reflection methods, integral transform methods
and numerical methods are demonstrated. Practical problems and
applications are emphasized.

MATH 434. Discrete Dynamical Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 300,
MATH 301, MATH 307 and MATH 310, each with a minimum grade of
C. Theory and applications of difference equations including existence
and uniqueness of solutions, linearization and stability, periodic solutions, and
bifurcations.

MATH 454. Using Technology in the Teaching of Mathematics. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits.
Prerequisites: MATH 200 and STAT 212, each with a minimum grade of
C; six additional credits in the mathematical sciences; and permission
of the instructor. Using graphing calculators, calculator-based labs and
computer software packages in teaching topics in algebra, geometry,
trigonometry, statistics, finance and calculus.

MATH 480. Methods of Applied Mathematics for the Life Sciences:
Discrete. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301,
MATH 307, MATH 310 and MATH 380, each with a minimum grade of C.
Focuses on the use of discrete dynamical system models to describe
phenomena in biology and medicine. Students will explore the theoretical
mathematics necessary to analyze these models. Computational
solutions to these models will be developed and implemented to validate
the models and to further explore the biological phenomena.

MATH 482. Methods of Applied Mathematics for the Life Sciences: PDE.
3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301,
MATH 307, MATH 310 and MATH 380, each with a minimum grade of C.
Focuses on the use of partial differential equation models to describe
phenomena in biology and medicine. Students will explore the theoretical
mathematics necessary to analyze these models. Computational
solutions to these models will be developed and implemented to validate
the model and to further explore the biological phenomena.

MATH 483. Methods of Applied Mathematics for the Life Sciences: ODE.
3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301,
MATH 307, MATH 310 and MATH 380, each with a minimum grade of C.
Focuses on the use of ordinary differential equation models to describe
phenomena in biology and medicine. Students will explore the theoretical
mathematics necessary to analyze these models. Computational
solutions to these models will be developed and implemented to validate
the models and to further explore the biological phenomena.