Mathematics

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There are many good reasons to study mathematics: preparation for a career, use in another field, or the beauty of the subject itself. Students at Colgate who major in mathematics go on to careers in medicine, law, or business administration as well as areas of industry and education having an orientation in science. Non-majors often require mathematical skills to carry on work in other disciplines, and all students can use the study of mathematics to assist them in forming habits of precise expression, in developing their ability to reason logically, and in learning how to deal with abstract concepts. There are also many people who view mathematics as an art form, to be studied for its own intrinsic beauty.

All mathematics courses are open to qualified students. Entering first-year students who have successfully completed at least three years of secondary school mathematics, including trigonometry, should be adequately prepared for **MATH 161.** Students who have studied calculus in secondary school are typically ready to enter **MATH 162** or **163.**

Major Program in Mathematics **MATH 161, 162** (or equivalent calculus experience approved by the department) is required for admission to a major or minor in mathematics.

The requirements for a major in mathematics are as follows:

1. **MATH 163** and **214** completed by the end of the sophomore year.
2. **MATH 250** completed by the end of the sophomore year with a grade of C or better.
3. **MATH 375** and **377** completed by the end of the junior year.
4. Four additional mathematics courses numbered **260** or above, excluding MATH 481, 482, 483.
5. To complete the major, each student must produce a thesis. This is normally done through **MATH 483**, but can also be done via an independent study at the 400-level (i.e., Math 491). Joint theses are allowed but will not normally be considered for honors. Exceptions may be made with departmental permission.

Majors who are planning to undertake graduate study in mathematics are advised to take **MATH 485** and **487.**

In unusual circumstances, the deadlines in items 2 and 3 may be extended with departmental approval through student petition to the department chair.

Major Program in Applied Mathematics **MATH 161, 162** (or equivalent calculus experience approved by the department) is required for admission to a major or minor in applied mathematics.
The requirements for a major in applied mathematics are as follows:

1. **MATH 163** and **214** completed by the end of the sophomore year.
2. **MATH 260** and **260L** completed by the end of the sophomore year with a grade of C or better.
3. **MATH 376** and **377** completed by the end of the junior year.
4. Three courses chosen from **MATH 250, 302, 308, 310, 312, 313, 315, 316, 408, 416, 449, 487.**
5. **Two cognate courses** representing a field of application interest outside of Mathematics. These two courses must count toward a single major in the Natural or Social Sciences preferably taken in two sequential semesters as the intent is to provide an immersive experience with the language, culture, questions, and ways of knowing of another field. The courses need not explicitly use mathematics, rather they provide a basis for communication with experts in that field. Normally, the senior research project (see 6, below) involves a topic related to this field of application.
6. To complete the major, each student must produce a thesis. This is normally done through **MATH 481** or **482**, but can also be done via an independent study at the 400-level (i.e., Math 491). Joint theses are allowed but will not normally be considered for honors. Exceptions may be made with departmental permission.

In unusual circumstances, the deadlines in items 2 and 3 may be extended with departmental approval through student petition to the department chair.

Minor Program in Mathematics The requirements for a minor in mathematics are as follows:

1. **MATH 163** and **214.**

2. **MATH 250** completed with a grade of C or better.
3. Either **MATH 375** or **377.**
4. Two other mathematics courses numbered **260** or above.

Minor Program in Applied Mathematics The requirements for a minor in applied mathematics are as follows:

1. **MATH 163** and **214.**
2. **MATH 260** completed with a grade of C or better.
3. **MATH 376.**
4. Two of the following courses: **MATH 250, 302, 308, 310, 312, 313, 315, 316, 408, 416, 449, 487.**

In order to graduate with a major in mathematics, a major in applied mathematics, a minor in mathematics, or a minor in applied mathematics, the student must have a GPA of at least 2.00 in mathematics courses counted for the major or minor.

The department also strongly recommends that students pursuing a major or a minor in mathematics complete **COSC 101** or its equivalent.

Honors and High Honors For a student to be considered for honors in Mathematics or in Applied Mathematics the student must achieve a 3.3 GPA in the respective major; in order for the student to be considered for high honors, a 3.7 GPA in the major is required. For both honors and high honors, completion of a course numbered 449 or above that is not a research seminar is required.

Honors / High Honors are attained by a student's production and defense of a thesis of distinction. A grade of A- or better is required to be considered for honors. In this situation, the student's thesis advisor puts forward the thesis for honors consideration. Subsequently, a committee of three faculty members, one being the student's thesis advisor, is formed.

The student must give a defense of the thesis, typically on the Wednesday during Finals week. The committee of three, with other math faculty acting in an advisory capacity with a recommendation, then grades the project, consisting of the thesis and defense.

In order for honors to be granted, the committee of three must unanimously grade the project as A- or better. In the event that all three grade the project as A or better, high honors will be granted. These are both contingent on satisfying the GPA and 449-level course requirements.

Joint theses are allowed but will not normally be considered for honors. Exceptions may be made with departmental permission.

As a reminder to the student writing theses for two different departments: In Colgate's Honor Code, it states: *Substantial portions of the same academic work may not be submitted for credit or honors more than once without the permission of the instructor(s).*

Awards See "Honors and Awards: Mathematics" in Chapter VI.

Calculus Placement Students should review the **MATH 161, 162,** and **163** course descriptions for information on topics and prerequisites, or consult with a department faculty member. In general, students are encouraged to enroll in a higher-level course. Students may drop back from **MATH 162** to **MATH 161** within the first three weeks, subject to available space in an acceptable **MATH 161** section.

Advanced Placement Students who have taken the Calculus-BC, Calculus-AB, or Statistics Advanced Placement exam of the College Entrance Examination Board will be granted credit according to the following policy:

1. Students earning 4 or 5 on the Calculus-BC Advanced Placement exam will receive credit for **MATH 161** and **162.** Students earning 3 on the Calculus BC exam will receive credit only for **MATH 161**.
2. Students earning 4 or 5 on the Calculus-AB Advanced Placement exam will receive credit for **MATH 161.**
3. Students earning 4 or 5 on the Statistics Advanced Placement exam will receive credit for **MATH 105.**
4. There are no other circumstances under which a student will receive credit at Colgate for a mathematics course taken in high school.

Transfer Credit Transfer credit for a mathematics course taken at another college will be granted upon the pre-approval of the department chair. Mathematics and Applied Mathematics majors or minors may not receive transfer credit for **MATH 250, 260, 375, 376,** or **377,** but must pass these courses *at Colgate* and must take them as regularly scheduled courses, not as independent studies.

At most two transfer or independent studies courses may be counted toward a major or minor.

International Exam Transfer Credit Transfer credit and/or placement appropriate to academic development of a student may be granted to incoming first year students who have achieved a score on an international exam (e.g., A-Levels, International Baccalaureate) that indicates a level of competence equivalent to the completion of a specific course in the department. Requests should be directed to the department chair. Any such credit may not be used to fulfill the university areas of inquiry requirement, but may count towards the major.

Teacher Certification The Department of Educational Studies offers a teacher education program for majors in mathematics who are interested in pursuing a career in elementary or secondary school teaching. Please refer to "Educational Studies."

Computer Science/Mathematics Major See "Computer Science."

Mathematical Economics Major See "Economics."

Mathematical Systems Biology Minor See "Mathematical Systems Biology."

Study Groups Colgate sponsors several study-abroad programs that can support continued work toward a major in mathematics. These include, but are not limited to, the Wales Study Group (U.K.), the Australia Study Group, the Australia II Study Group, and the Manchester Study Group (U.K.). For more information about these programs, see "Off-Campus Study" in Chapter VI.

Course Offerings

Our course numberings have changed to better guide students. We use the following classification scheme for our courses:

100-149: Only requires knowledge of mathematics before Calculus

150-199: Calculus-level knowledge and/or sophistication

200-249: Linear Algebra level (gentle transition-type course)

250-299: Transition to the major level

300-349: Courses with requirements at Math 150-249 level

350-399: Courses with requirements at the Math 250-299 level

400-449: Courses with requirements at the Math 300-349 level

450-474: Courses with requirements at the Math 350-399 level

475-484: Research experience seminars

485-499: Advanced material

MATH 105 - Introduction to Statistics

This course is an introduction to the basic concepts of statistics. Topics include experimental design, descriptive statistics, correlation, regression, basic probability, mean tendencies, the central limit theorem, point estimation with errors, hypothesis testing for means, proportions, paired data, and the chi-squared test for independence. Emphasis is on statistical reasoning rather than computation, although computation is done via software.

Credits: 1.00
Corequisite: Introduction to Statistics
Prerequisites: None
Three years of secondary school mathematics
FOS Restriction: None
Class Restriction: None

Restrictions: Not open to students who have either received credit for or are currently enrolled in CORE 143S or MATH 316 or MATH 416 (formerly MATH 317).
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 149 - Mathematical Deliberation

The emphasis throughout this course is the development of the ability to think creatively - to solve mathematical exercises that must be stated as a mathematical model (the creative thinking aspect) and then solved using techniques encountered during a student's secondary educational experience in mathematics in the courses known as algebra, plane geometry, trigonometry and elementary functions. An inspiration for this offering reflects the ability of computers and calculators to carry out many of the mathematical techniques needed to obtain a solution to a mathematical model - it is the modeling aspect that is now the stumbling block to solving mathematically posed problems and it has always been the more difficult aspect to address when solutions to problems (especially "word" problems) are requested.

Credits: 1.00
When Offered: Sporadic

Corequisite: Mathematical Deliberation
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 161 - Calculus I

In this course students are introduced to the basic concepts of differential and integral calculus including limits and continuity; differentiation of algebraic, trigonometric, exponential, and logarithmic functions; applications of the derivative to curve sketching, related rates, and maximum-minimum problems; Riemann sums and the definite integral; and the fundamental theorem of calculus.

Credits: 1.00
Corequisite: Calculus I
Prerequisites: None
Three years of secondary school mathematics including trigonometry
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 162 - Calculus II

This course continues the study of calculus begun in MATH 161. Topics covered include the calculus of inverse trigonometric functions, techniques of integration, improper integrals, l'Hôpital's rule and indeterminate forms, applica-

tions of integration, and Taylor series.

Credits: 1.00
Corequisite: Calculus II
Prerequisites: None
MATH 161 with a grade of C- or higher or equivalent experience in a secondary school calculus course
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 163 - Multivariable Calculus

The content from MATH 162 and 163 is extended to several variables. Among the topics considered are surfaces in three-dimensional space, partial derivatives, maxima and minima, and multiple integrals.

Credits: 1.00
Corequisite: Multivariable Calculus
Prerequisites: None
MATH 162 with a grade of C- or higher or equivalent experience in a secondary school calculus course or concurrent enrollment in PHYS 232
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 214 - Linear Algebra

Linear Algebra is the study of sets of linear equations and their transformation properties over vector spaces. Topics include: systems of linear equations, matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and diagonalization.

Credits: 1.00
Corequisite: Linear Algebra
Prerequisites: MATH 163
(may be taken concurrently)
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 250 - Number Theory and Mathematical Reasoning

Questions about the positive integers 1, 2, 3 . . . have fascinated people for thousands of years. The ancient Greeks noted the existence of right triangles with sides of integral length. Is there a way of describing all such "Pythagorean Triples"? None of the primes 7, 11, or 19 can be expressed as the sum of two squares. Is there a pattern? Does it continue forever? This course focuses on such equations as a means for introducing students to the spirit and methods of

modern mathematics. The emphasis throughout is on developing the ability to construct logically sound mathematical arguments and communicate these arguments in writing.

Credits: 1.00
Corequisite: Number Theory and Mathematical Reasoning
Prerequisites: MATH 162 or MATH 163
with a grade of C or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 260 – Computational Mathematics

This course is an exploration of computer manipulation and presentation of mathematical ideas. The computer allows mathematics to be explored, manipulated and connected to data. No background in programming is presumed. Students learn how numbers are stored and manipulated on the computer in order to do mathematics (from calculus to linear algebra to exploring patterns in the integers), how mathematical functions can be encoded and presented, and how data relates to functions. Induction and continuity are methods of proof relying on infinity, yet will be explored using the finite number cruncher called a computer. The results provide examples and intuition for further mathematical investigation. The required lab portion of the course allows students to implement these ideas in practice.

Credits: 1.00
Corequisite: MATH 260L
Prerequisites: MATH 162 and MATH 163
FOS Restriction: None
Class Restriction: No Junior, Senior
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 260L - Mathematical Computing Lab

Required corequisite to MATH 260.

Credits: 0.25
Corequisite: MATH 260
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 291 - Independent Study

Opportunity for individual study in areas not covered by formal course offerings, under the guidance of a member of the faculty.

Credits: variable

Corequisite: Independent Study
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 302 - Systems Biology

Systems biology is an emerging interdisciplinary field that focuses on system level understanding of complex interactions of biological processes using quantitative approaches. The course focuses on the applications of mathematical techniques such as differential equations, network structure measures, machine learning and modeling (e.g., Boolean and stochastic modeling) to the study of gene regulation, synthetic gene circuits, small- and large-scale biological networks, and signal transduction pathways. Students also learn how to use computer software that is designed for biological data analysis such as GenePattern and COPASI.

Credits: 1.00
When Offered: Fall semester only, in alternate years
Crosslisted: BIOL 302
Corequisite: Systems Biology
Prerequisites: (MATH 161 or MATH 162) and (BIOL 182 or BIOL 212 or MATH 163 or PHYS 204 or COSC 101)
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 308 - Differential Equations

This course presents a study of equations that include derivatives. Techniques for solving, and the theory of, ordinary differential equations are presented. Topics include: first order equations with associated initial conditions, linear second order equations with constant coefficients, systems of differential equations, and applications.

Credits: 1.00
Corequisite: Differential Equations
Prerequisites: MATH 162 and MATH 163
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 310 - Combinatorial Problem Solving

This course develops methods to solve combinatorial (finite) problems arising in mathematics, computer science, and other areas from the natural and social sciences. Enumeration and graph theory are the main subjects. Topics include recurrence relations, generating functions, inclusion-exclusion, modeling with graphs, trees and searching, graph coloring, and network algorithms. The emphasis is on problem solving rather than theory.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Combinatorial Problem Solving
Prerequisites: MATH 162
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 312 - Math Modeling: Social Sciences

How do we translate problems from the world into solvable mathematical problems? Mathematical modeling is the art of creating mathematical problems whose solutions are useful for real world problems. Methods such as scaling, qualitative analysis, limits of predictability, and simple random models are discussed. Applications considered arise from economics, political science, and sociology.

Credits: 1.00
When Offered: Spring semester only

Corequisite: Math Modeling: Social Sciences
Prerequisites: MATH 214
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 313 - Functions of a Complex Variable

By introducing the imaginary number $i = \sqrt{-1}$ the analysis of functions over the complex plane becomes, at times, distinctly different than over the real plane. Topics include complex numbers and functions, the theory of differentiation and integration of complex functions, sequences and series of complex functions, conformal mapping. Special attention is given to Cauchy's integral theorem.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Functions of a Complex Variable
Prerequisites: MATH 162 and MATH 163
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 315 - Mathematical Biology

Mathematical biology is a fast growing and interdisciplinary area in which mathematics is utilized as a tool for studying various biological phenomena such as population growth, infectious diseases, the spread of invasive species, cell movement, dynamics of a neuron, etc. This course provides an introduction to the basics of discrete and continuous models and mathematical concepts for students to learn how to derive, interpret, solve, simulate, and understand

models of biological systems.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Mathematical Biology
Prerequisites: MATH 162 and MATH 163
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 316 - Probability

This course gives an introduction to the basic concepts of discrete and continuous probability: axioms and properties of probability, standard counting techniques, conditional probability, important random variables and their discrete and continuous distributions, expectation, variance, and joint distribution functions. Additional topics may include: Poisson processes, Markov chains, and Monte Carlo methods.

Credits: 1.00
When Offered: Fall semester only

Corequisite: Probability
Prerequisites: MATH 162 and MATH 163
(MATH 163 may be taken concurrently)
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 357 – Geometry

This course contains a study of several geometrical systems, with emphasis upon a rigorous development of Euclidean geometry.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Geometry
Prerequisites: MATH 250
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 375 - Abstract Algebra I

Abstract algebraic structures, rather than results specific to the usual number systems, are developed. Basic algebraic structures presented include groups, rings, integral domains, and fields.

Credits: 1.00

Corequisite: Abstract Algebra I
Prerequisites: MATH 250
with a grade of C or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 376 - Numerical Analysis

This course provides an introductory treatment of methods used for numerical approximation. Topics include roots of equations, simultaneous linear equations, quadrature, and other fundamental processes using high speed computing devices.

Credits: 1.00
When Offered: Fall semester only

Corequisite: Numerical Analysis
Prerequisites: MATH 260
with a grade of C or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 377 - Real Analysis I

Results from calculus , including limits, continuity, the derivative, and the Riemann integral, are given a rigorous treatment.

Credits: 1.00

Corequisite: Real Analysis I
Prerequisites: MATH 162 and MATH 163 and (MATH 250 or MATH 260)
MATH 250 or MATH 260 with a grade of C or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 382 - Topology

This course provides an introduction to both point-set topology and basic algebraic topology. Topics include metric spaces, topological spaces, compactness, connectedness, the classification of surfaces, mod-2 homology, and the Jordan curve theorem. Additional topics that demonstrate connections with analysis, dynamics, and algebra are determined by the instructor based on student interest.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Topology
Prerequisites: MATH 250
with a grade of C or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 391 - Independent Study

Opportunity for individual study in areas not covered by formal course offerings, under the guidance of a member of the faculty.

Credits: variable
Corequisite: Independent Study
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 399 - Mathematical Problem Solving

This capstone seminar gives students a research experience through work on a semester-long problem. Students are expected to attend weekly progress meetings with the instructor.

Credits: 1.00
Corequisite: Mathematical Problem Solving
Prerequisites: MATH 250 and (MATH 375 or MATH 377)
FOS Restriction: None
Class Restriction: Only Senior
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 408 - Partial Differential Equations

This course explores mathematics as it is applied to the physical sciences. Mathematical topics may include boundary

value problems, partial differential equations, special functions, Fourier series and transforms, Green's functions, and approximate solution methods.

Credits: 1.00
When Offered: Spring semester only, in alternate years

Corequisite: Partial Differential Equations
Prerequisites: MATH 308
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 410 - Ramsey Theory on the Integers

Ramsey theory, in a broad sense, is the study of structures of mathematical objects that are preserved under partitions. Many results in Ramsey theory sound rather complicated and can be hard to follow; they tend to have a lot of quantifiers and may well involve objects whose elements are sets. However, when the objects under consideration are sets of integers, the situation is much simpler. This course will offer students a glimpse into the world of mathematical research and the opportunity for them to begin pondering unsolved problems.

Credits: 1.00
When Offered: Spring semester only, in alternate years
Corequisite: Ramsey Theory on the Integers
Prerequisites: MATH 310 or MATH 375
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 416 - Mathematical Statistics

The standard methods in statistics are developed with mathematical rigor. Topics include parameter estimation, including Bayesian estimation, the Central Limit Theorem, hypothesis testing, regression, analysis of variance, and nonparametric statistics. Applications of these tools are studied, with the choice of topics determined by the instructor.

Credits: 1.00
When Offered: Spring semester only, in alternate years

Corequisite: Mathematical Statistics
Prerequisites: MATH 316
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 449 - Nonlinear Dynamics and Chaos

This course gives an introduction to the techniques and concepts used to analyze real-time dynamic models that involve nonlinear terms. Applications are emphasized and demonstrate the universality of chaotic solution behavior. This course is team-taught by members of the physics and mathematics departments.

Credits: 1.00
Crosslisted: PHYS 458
When Offered: Spring semester only, in alternate years

Corequisite: Nonlinear Dynamics and Chaos
Prerequisites: MATH 308 or PHYS 302 or PHYS 431
FOS Restriction: None
Class Restriction: None
Recommended: Students should enroll through the department for which they intend to use the credit.

Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 450 - Number Theory II

This course continues the study of number theory begun in MATH 250 and includes the Quadratic Reciprocity Law of Gauss, the Cubic Reciprocity Law of Eisenstein and Jacobi, and other topics from algebraic number theory.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Number Theory II
Prerequisites: MATH 375
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 481 - Modeling of Biological Systems

Quantitative techniques have become a crucial tool in recent years for analyzing biological systems, a field which has been flooded with highly detailed experimental data due to new advanced data acquisition techniques in the biological sciences. This interdisciplinary research tutorial explores the analysis of biological systems using quantitative approaches such as mathematical modeling, statistical learning, and computer programming. With the guidance of the instructor, students choose a biological problem of their interest and analyze it using quantitative techniques. The research topics include (but are not limited to) gene regulation, disease networks, and cell cycle regulation. Students are expected to read the primary literature related to their research project, write a paper describing their research in the format of a scientific journal article, present the results of their research, and write a peer-reviewed grant proposal.

Credits: 1.00
When Offered: Spring semester only
Crosslisted: BIOL 481
Corequisite: Modeling of Biological Systems
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Restrictions: Permission of instructor
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 482 – Research Seminar: Applied Mathematics

Credits: 1.00
When Offered: Fall semester only

Corequisite: Research Seminar: Applied Mathematics
Prerequisites: MATH 376 and MATH 377
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

This capstone seminar presents our senior Applied Mathematics majors with a research experience in applied mathematics. Each student will work closely with the instructor on a research problem that will require the integration of previously developed applied mathematics skills. Students will apply their learning from previous math courses toward a specified research problem and will delve deeply into material related to the specific problem. Each student will craft a succinctly written, convincing piece of mathematics addressing their research problem and will present their work as a final thesis.

MATH 483 – Research Seminar: Mathematics

Credits: 1.00
When Offered: Fall semester only

Corequisite: Research Seminar: Mathematics
Prerequisites: MATH 375 and MATH 377
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

This capstone seminar presents our senior Mathematics majors with a research experience in mathematics. Each student will work closely with the instructor on a research problem that will require the integration of previously developed mathematics skills. Students will apply their learning from previous math courses toward a specified research problem and will delve deeply into material related to the specific problem. Each student will craft a succinctly writ-

ten, convincing piece of mathematics addressing their research problem and will present their work as a final thesis.

MATH 485 - Abstract Algebra II

This course continues the study of abstract algebraic structures, providing a careful and intensive study of topics such as group theory, ring theory, field theory, and Galois theory.

Credits: 1.00
When Offered: Spring semester only, in alternate years

Corequisite: Abstract Algebra II
Prerequisites: MATH 375
with a grade of B or better
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 487 - Real Analysis II

Topics for this course are selected from among the following: metric spaces, sequences and series of functions, the Lebesgue integral.

Credits: 1.00
When Offered: Spring semester only, in alternate years

Corequisite: Real Analysis II
Prerequisites: MATH 377
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 491 - Independent Study

Opportunity for individual study in areas not covered by formal course offerings, under the guidance of a member of the faculty.

Credits: variable
Corequisite: Independent Study
Prerequisites: None
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None

MATH 499 - Mathematical Logic

The topics covered in this course include the following: propositional and predicate calculus, completeness and com-

pactness theorems, the foundations of nonstandard analysis, first-order model theory, recursive functions, a full proof of Godel's Incompleteness Theorem, and undecidability.

Credits: 1.00
When Offered: Fall semester only, in alternate years

Corequisite: Mathematical Logic
Prerequisites: MATH 320
and permission of instructor
FOS Restriction: None
Class Restriction: None
Area of Inquiry: Natural Sciences & Mathematics
Liberal Arts CORE: None