MATHEMATICS (MATH)

Faculty

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Mathematics has long been the language of the natural sciences and has been studied for its own sake since ancient times. Statistics is the foundational tool for understanding and analyzing data from a wide variety of sources, and also an area of active research in its own right. An understanding of the basics of calculus, statistics, and linear algebra has become a requirement for proficiency in many of the social sciences. The study of mathematics or statistics has rewards because accomplishment in the subjects, even at a relatively elementary level, requires and promotes clarity of both thought and expression. For many, the study of mathematics offers entrance into an exciting world of challenges where beauty and utility coexist in balanced harmony. The study of statistics is the bridge between data and understanding and offers insights otherwise unobtainable.

A major in mathematics, applied mathematics or statistics may be seen as the first step toward obtaining a graduate degree in one of the mathematical sciences, or it may constitute preparation for a professional degree program in a field such as education, medicine, law, or business. It also opens the door to a whole range of employment opportunities, as the analytical skills that a student develops in pursuing these majors are greatly valued by potential employers. There are, for example, excellent career prospects in actuarial work and in the rapidly growing areas of analytics, biomathematics and biostatistics, modeling (in industry, government, and finance), and cryptology (in banking, television, the Internet, and elsewhere).

Mathematics Majors and Statistics Majors

The Mathematics Department offers four majors. Students may earn a Bachelor of Arts in Mathematics, a Bachelor of Science in Mathematics, a Bachelor of Science in Applied Mathematical Sciences, or a Bachelor of Science in Statistics. The choice of degree program depends largely upon the student's mathematical or statistical objectives and interests in fields other than mathematics. Students with strong interests outside mathematics have options including a Bachelor of Science in Applied Mathematical Sciences, a Bachelor of Arts in Mathematics, or a Bachelor of Science in the Mathematical Economics (http://coursecatalog.bucknell.edu/archive/2020-2021/collegeofartsandsciencescurricula/areasofstudy/interdisciplinarystudiesineconomicsandmathematicsecma) program.

Students in each major complete an introductory year of calculus during their first year, or fulfill this requirement by achieving a high score on the Advanced Placement Test of the College Entrance Examination Board. Students with a strong interest in a career in mathematics or science – and in particular, students planning to continue on to Ph.D. programs in the mathematical sciences – are strongly advised to take courses beyond the minimum requirements for the major. Since the number of courses to be taken in any one department is restricted to 12 for a Bachelor of Arts degree, such students are advised to choose one of the Bachelor of Science majors.

Bachelor of Arts in Mathematics

The **Bachelor of Arts in Mathematics** major consists of eight mathematics courses beyond the introductory year of calculus, plus one additional course in a related field and a Culminating Experience.

Of the eight mathematics courses beyond the introductory year of calculus, five are specified:

Program Requirements		
MATH 211	Calculus III	1
MATH 245	Linear Algebra	1
MATH 280	Logic, Sets, and Proofs	1
MATH 308	Real Analysis I	1
MATH 320	Abstract Algebra I	1
Electives		
Three electives at the 300 or 400 level		3
Related Field Course		
Select one of the following:		1
Fourth Mathematics course at the 300 or 400 level		
MATH 207	The Teaching of Mathematics in Secondary Schools	
MATH 212	Differential Equations	
MATH 216	Statistics I	

MATH 217	Statistics II	
MATH 219	Topics in Applied Mathematics	
MATH 230	Data Visualization & Computing	
An additional full-credit course in which college-level mathematics or statistics plays a major role. [1]		
A Culminating Experience [2]		
Total Credits: 11-12		

[1] Examples include any computer science or science course (beyond those required for all liberal arts students), including nearly all courses in computer science or physics at or above the 200 level, or an appropriate course from humanities, social sciences, or engineering in which mathematics plays a significant role at a reasonable level of sophistication.

[2] The requirement for a *Culminating Experience* within the major may be satisfied in any of the following ways: (1) taking a full credit 400-level mathematics course; or (2) completing a guided research project, such as an honors thesis, in mathematics, statistics, mathematics education, or applied mathematics. This project should extend beyond one semester and include an initial proposal, a final product, and a public presentation of results; or (3) completing student teaching for secondary certification. The Culminating Experience may be non-credit bearing. Students earning a Bachelor of Arts in Mathematics may count a 400-level mathematics course both as their mathematics-related course and as the Culminating Experience. A single 400-level course may be used to satisfy both the Culminating Experience requirement and the related course requirement. The Culminating Experience may be undertaken in the spring of junior year or the fall or spring of senior year.

The mathematics department chair shall make the determination of whether or not a particular course outside the mathematics department may count as the course in a related field.

The College Core Curriculum disciplinary depth requirements for Bachelor of Arts major are satisfied as follows:

- *writing within the major* in MATH 280 Logic, Sets, and Proofs, MATH 308 Real Analysis I, and MATH 320 Abstract Algebra I (all W2 courses);
- *information literacy* in MATH 308 Real Analysis I and MATH 320 Abstract Algebra I;
- *formal presentation* as part of the culminating experience.

Students with a special interest in pure mathematics or statistics may earn formal concentration in these areas by completing an appropriate suite of 300 and 400-level courses, as described below.

Pure Mathematics Concentration

MATH 345	Advanced Linear Algebra	1
MATH 409	Real Analysis II	1
MATH 446	Abstract Algebra II	1
Select two of the following:		2
MATH 311	Theory of Numbers	
MATH 333	Topology	
MATH 362	Complex Analysis	

Statistics Concentration

MATH 303	Probability	1
MATH 304	Statistical Inference Theory	1
Three courses from the following, subject to: at least one of MATH 405 and MATH 407, and no more than one of MATH 345 and MATH 409 may count toward this requirement.		3
MATH 306	Bayesian Statistics	
MATH 345	Advanced Linear Algebra	
MATH 354	Modern Data Analysis	
MATH 405	Statistical Modeling	
MATH 407	Statistical Design of Scientific Studies	
MATH 409	Real Analysis II	

Bachelor of Science in Mathematics

The **Bachelor of Science in Mathematics** major requires 10 mathematics courses beyond the introductory year of calculus, a computing course, two physics courses, an additional lab science course, and a Culminating Experience.

Six of the 10 mathematics courses are specified:

Program Requirements		
MATH 211	Calculus III	1
MATH 212	Differential Equations	1
MATH 245	Linear Algebra	1
MATH 280	Logic, Sets, and Proofs	1
MATH 308	Real Analysis I	1
MATH 320	Abstract Algebra I	1
Electives		
Four mathematics electives at the 300 or 400 level		4
PHYS 211	Classical and Modern Physics I	1
Select one of the following:		1
PHYS 212	Classical and Modern Physics II	
or PHYS 212E	Classical and Modern Physics II	
CSCI 203	Introduction to Computer Science	1
One additional laboratory science course. [3]		1
A Culminating Experience. [4]		

[3] The additional laboratory science course may be chosen from any discipline in the natural sciences or from computer science. Any course in physics beyond PHYS 212 Classical and Modern Physics II, and any laboratory course in computer science beyond CSCI 203 Introduction to Computer Science, may be chosen.

[4] The requirement for a *Culminating Experience* within the major may be satisfied in any of the following ways: (1) taking a full credit 400-level mathematics course; or (2) completing a guided research project, such as an honors thesis, in mathematics, statistics, mathematics education, or applied mathematics. This project should extend beyond one semester and include an initial proposal, a final product, and a public presentation of results; or (3) completing student teaching for secondary certification. The Culminating Experience may be non-credit bearing. The Culminating Experience cannot double-count as one of the mathematics electives required in the major. The course for a Culminating Experience may be undertaken in the spring of junior year or the fall or spring of senior year.

The College Core Curriculum disciplinary depth requirements for Bachelor of Science major are satisfied as follows:

- *writing within the major* in MATH 280 Logic, Sets, and Proofs, MATH 308 Real Analysis I, and MATH 320 Abstract Algebra I (all W2 courses);
- *information literacy* in MATH 308 Real Analysis I and MATH 320 Abstract Algebra I;
- *formal presentation* as part of the culminating experience.

Students with a special interest in pure mathematics or statistics may earn formal concentration in these areas by completing an appropriate suite of 300 and 400-level courses, as described below. In particular, those intending to pursue graduate study in mathematics or statistics should plan to complete the relevant concentration.

Pure Mathematics Concentration

MATH 345	Advanced Linear Algebra	1
MATH 409	Real Analysis II	1
MATH 446	Abstract Algebra II	1
Select two of the following:		2
MATH 311	Theory of Numbers	
MATH 333	Topology	
MATH 362	Complex Analysis	

Statistics Concentration

MATH 303	Probability	1
MATH 304	Statistical Inference Theory	1
Three courses from the following, subject to: at least one of MATH 405 and MATH 407, and no more than one of MATH 345 and MATH 409 may count toward this requirement		3
MATH 306	Bayesian Statistics	
MATH 345	Advanced Linear Algebra	
MATH 354	Modern Data Analysis	
MATH 405	Statistical Modeling	

MATH 407	Statistical Design of Scientific Studies
MATH 409	Real Analysis II

A sample sequence for the Bachelor of Science in Mathematics major is provided below. It should be noted that each student's sequence will be unique, depending on when the program is started, how many AP or transfer credits are applied, and when the desired courses are offered.

First Year			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 201	1	MATH 202	1
PHYS 211	1	PHYS 212	1
	2		2
Sophomore			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 211	1	MATH 212	1
MATH 245	1	MATH 280	1
CSCI 203	1	Laboratory science	1
	3		3
Junior			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 308 or 320	1	MATH 308 or 320	1
Elective in mathematics	1	Elective in mathematics	1
	2		2
Senior			
First Semester	**Credits**	**Second Semester**	**Credits**
Elective in mathematics	1	Elective in mathematics	1
		Culminating Experience	1
	1		2

Total Credits: 17

Bachelor of Science in Applied Mathematical Sciences

The **Bachelor of Science in Applied Mathematical Sciences** major (with a concentration in statistics or applied mathematics) requires 10 mathematics courses beyond the introductory year of calculus, a computing course, at least five approved courses in an approved program, and a Culminating Experience. More specifically, there are six required core mathematics courses consisting of:

Program Requirements		
MATH 211	Calculus III	1
MATH 216	Statistics I	1
MATH 245	Linear Algebra	1
MATH 280	Logic, Sets, and Proofs	1
MATH 303	Probability	1
MATH 308	Real Analysis I	1
Courses in Area of Concentration		
Four concentration-related courses in statistics or applied mathematics		4
A Culminating Experience [5]		

[5] The requirement for a *Culminating Experience* within the major may be satisfied in any of the following ways: (1) taking a full credit 400-level mathematics course; or (2) completing a guided research project, such as an honors thesis, in mathematics, statistics, mathematics education, or applied mathematics. This project should extend beyond one semester and include an initial proposal, a final product, and a public presentation of results; or (3) completing student teaching for secondary certification. The Culminating Experience may be non-credit bearing. The Culminating Experience cannot double-count as one of the mathematics electives required in the major. While the Culminating Experience may be met in any of the ways specified above, students earning a Bachelor of Science in Applied Mathematical Sciences are strongly encouraged to consider the option of a thesis or research experience integrating the outside coursework. The course for a Culminating Experience may be undertaken in the Spring of Junior Year or the Fall or Spring of Senior Year.

Further, the major requires a computing course and significant coursework in an approved outside department or program as described below. While the Culminating Experience may be met in any of the ways specified above, students earning a Bachelor of Science in Applied Mathematical Sciences are strongly encouraged to consider the option of a thesis or research experience integrating the outside coursework.

The College Core Curriculum disciplinary depth requirements for Bachelor of Science in Applied Mathematical Sciences major are satisfied as follows:

- *writing within the major* in MATH 216 Statistics I, MATH 280 Logic, Sets, and Proofs, and MATH 308 Real Analysis I (all W2 courses);
- *information literacy* in MATH 308 Real Analysis I;
- *formal presentation* as part of the culminating experience.

Statistics Concentration

MATH 217	Statistics II	1
MATH 304	Statistical Inference Theory	1
Select two of the following: [6]		2
MATH 306	Bayesian Statistics	
MATH 345	Advanced Linear Algebra	
MATH 354	Modern Data Analysis	
MATH 358	Topics in Operations Research	
MATH 405	Statistical Modeling	
MATH 407	Statistical Design of Scientific Studies	
MATH 409	Real Analysis II	

[6] At least one course must be selected from MATH 405 Statistical Modeling and MATH 407 Statistical Design of Scientific Studies.

Alternative 300 or 400-level mathematics courses could count toward the concentration if deemed appropriate by the academic adviser in consultation with the mathematics department chair.

Applied Mathematics Concentration

MATH 212	Differential Equations	1
Select three of the following:		3
MATH 343	Numerical Analysis	
MATH 345	Advanced Linear Algebra	
MATH 350	Methods in Applied Mathematics	
MATH 358	Topics in Operations Research	
MATH 362	Complex Analysis	
MATH 409	Real Analysis II	
MATH 416	Modern Applied Mathematics	

Alternative 300 or 400-level mathematics courses could count toward the concentration if deemed appropriate by the academic adviser in consultation with the mathematics department chair.

The **computing course** can be a computer science course at or above the 200-level or a computing course appropriate to the program of study as determined through consultation with the academic adviser and the mathematics department chair.

Outside Coursework

For the purpose of completing a coherent sequence of courses that provide a solid introduction to the discipline, all students must partner with an approved department or program in a discipline that applies statistics or mathematics. In this regard, a minimum of five approved courses chosen in consultation with the mathematics department adviser and the outside department or program is required. A partner department/program will usually be chosen from the College of Engineering, the Freeman College of Management, the Division of Social Sciences, or the Division of Natural Sciences. Entering students may declare the intended major in the summer after acceptance to Bucknell, but must consult with the mathematics department and formally declare the outside coursework by the end of their third semester. All other students must consult with the mathematics department at the point of declaring the major and specify the outside coursework. In either case, the mathematics department will consult with the partner department or program to ensure that the coursework is appropriate and can be completed.

A sample sequence for the Bachelor of Science in Applied Mathematical Sciences major is provided below. It should be noted that each student's sequence will be unique, depending on when the program is started, how many AP or transfer credits are applied, and when the desired courses are offered.

First Year

First Semester	Credits	Second Semester	Credits
MATH 201	1	MATH 202	1
		MATH 216	1
	1		2

Sophomore

First Semester	Credits	Second Semester	Credits
MATH 211	1	MATH 245	1
Computing course	1	MATH 303	1
MATH 217 (if following the statistics concentration)	1	Outside course	1
	3-2		3

Junior

First Semester	Credits	Second Semester	Credits
MATH 280	1	MATH 308	1
Outside course	1	Concentration course	1
MATH 212 (If following the applied concentration)	1	Outside course	1
	3-2		3

Senior

First Semester	Credits	Second Semester	Credits
Concentration course	1	Concentration course	1
Outside course	1	Outside course	1
		Culminating Experience	1
	2		3

Total Credits: 20-18

Bachelor of Science in Statistics

The **Bachelor of Science in Statistics** major requires 13 mathematics and statistics courses beyond the introductory year of calculus, a computing course, and a Culminating Experience, which may double-count with one of the 400-level requirements or electives.

Ten of the 13 mathematics and statistics courses are specified:

MATH 211	Calculus III	1
MATH 216	Statistics I	1
MATH 217	Statistics II	1
MATH 230	Data Visualization & Computing	1
MATH 245	Linear Algebra	1
MATH 280	Logic, Sets, and Proofs	1
MATH 303	Probability	1
MATH 304	Statistical Inference Theory	1
MATH 308	Real Analysis I	1
MATH 405	Statistical Modeling	1
Three elective courses from the following list, two of which must be selected from MATH 306, MATH 354, MATH 407, or MATH 409		3
MATH 306	Bayesian Statistics	
MATH 345	Advanced Linear Algebra	
MATH 354	Modern Data Analysis	
MATH 358	Topics in Operations Research	
MATH 407	Statistical Design of Scientific Studies	
MATH 409	Real Analysis II	
Required Computer Science Course		
CSCI 203	Introduction to Computer Science	

Total Credits: 16-17

The requirement for a Culminating Experience within the major may be satisfied in any of the following ways: (1) taking one of the courses MATH 405 Statistical Modeling, MATH 407 Statistical Design of Scientific Studies, or MATH 409 Real Analysis II; or (2) completing a guided research project, such as an honors thesis, in statistics or a related area as determined by the department. This project should extend beyond one semester and include an initial proposal, a final product, and a public presentation of results. The Culminating Experience may be non-credit bearing. The Culminating Experience may double-count with MATH 405 Statistical Modeling or with one of the 400-level mathematics electives listed for the major. The Culminating Experience may be undertaken in the spring of junior year or the fall or spring of senior year.

The College Core Curriculum disciplinary depth requirements for Bachelor of Science in Statistics major are satisfied as follows:

- *writing within the major* in MATH 216 Statistics I, MATH 280 Logic, Sets, and Proofs, MATH 308 Real Analysis I (all W2 courses);
- *information literacy* in MATH 308 Real Analysis I;
- *formal presentation* as part of the culminating experience.

A sample sequence for the Bachelor of Science in Statistics major is provided below. It should be noted that each student's sequence will be unique, depending on when the program is started, how many AP or transfer credits are applied, and when the desired courses are offered.

First Year			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 201	1	MATH 202	1
CSCI 203	1	MATH 216	1
	2		2
Sophomore			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 211	1	MATH 230	1
MATH 217	1	MATH 280	1
	2		2
Junior			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 245	1	MATH 304	1
MATH 303	1	MATH 308	1
		Culminating Experience[1]	0-1
	2		2-3
Senior			
First Semester	**Credits**	**Second Semester**	**Credits**
MATH 405	1	Elective 2	
Elective 1		MATH 345, 358, 407, or 409	1
MATH 306, 354, 345, or 409	1	Elective 3	
		MATH 345, 358, 407, or 409	1
	2		2

Total Credits: 16-17

[1] Please note the culminating experience may be taken in the spring of the junior year or in the fall or spring of the senior year.

Departmental Honors

Students who complete departmental honors should have a grade point average of at least 3.5 both in their mathematics courses and overall. By the end of their junior year, students in the Bachelor of Arts in Mathematics major or Bachelor of Science in Mathematics major must have completed a total of at least three mathematics courses at the 300- or 400-level, including MATH 308 Real Analysis I or MATH 320 Abstract Algebra I. Students in the Bachelor of Science in Applied Mathematical Sciences major must have completed a total of at least three mathematics courses at the 300- or 400- level by the end of their junior year; two such courses suffice if one of them is MATH 308 Real Analysis I. By the end of their junior year, students in the Bachelor of Science in Statistics major must have completed a total of at least three mathematics courses at the 300- or 400-level, including MATH 308 Real Analysis I. To be accepted into the Honors Program, a student must satisfy all other requirements as put forth by the University Honors Council. The student must then complete an honors thesis under the adviser's direction and pass a thesis examination in accordance with the requirements of the University Honors Council. Such students may earn course credit for their thesis work by signing up for at least one half-credit of independent study per semester.

Secondary Teacher Certification

Prospective secondary school teachers (grades 7 – 12) must complete one of the four majors within the department. This certification requires specific mathematics and education courses. Students seeking teacher certification should confer as early as possible with the mathematics

and education departments to devise a program of study, which normally will include all requirements for certification in the Commonwealth of Pennsylvania.

Mathematics Minor

A **minor** in Mathematics consists of either:

MATH courses MATH 211 or above (at least one of them at the 300 or 400 level)	4
Total Credits	4

or

MATH courses MATH 211 or above (at least two of them at the 300 or 400 level)	3
Total Credits	3

All credits must come from courses taken at Bucknell University.

Mathematics (Statistics) Specific Minor

The minor can be specified as Mathematics (statistics), if at least two of the required credits are from among the following list, with no more than than one credit from MATH 217 Statistics II and MATH 230 Data Visualization & Computing:

MATH 217	Statistics II	1
MATH 230	Data Visualization & Computing	1
MATH 303	Probability	1
MATH 304	Statistical Inference Theory	1
MATH 306	Bayesian Statistics	1
MATH 354	Modern Data Analysis	1
MATH 405	Statistical Modeling	1
MATH 407	Statistical Design of Scientific Studies	1

Mathematics (Applied/Modeling Mathematics) Specific Minor

The minor can be specified as Mathematics (applied/modeling mathematics) if at least two of the required credits are from among the courses:

MATH 212	Differential Equations	1
MATH 219	Topics in Applied Mathematics	1
MATH 343	Numerical Analysis	1
MATH 350	Methods in Applied Mathematics	1
MATH 358	Topics in Operations Research	1

The Department of Mathematics aims to provide both majors and non-majors with the mathematical and statistical knowledge and skills needed to succeed in their chosen field of endeavor. It is also intended that the student experience the elegance and broader impacts of the discipline.

Students earning a BA or BS in Mathematics, a BS in Applied Mathematical Sciences, or a BS in Statistics, will:

1. Demonstrate knowledge of the principal definitions and theorems in the canon of undergraduate mathematical sciences (1, 6)

2. Be able to communicate mathematical thought (1, 7)

3. Apply effectively appropriate quantitative tools and logical modes of thinking to analyze and synthesize information in problem solving situations (1, 2, 6)

4. Experience the breadth of mathematics and statistics (2, 9)

Numbers in parentheses refer to related Bucknell University Educational Goals (https://coursecatalog.bucknell.edu/educationalgoals).

Courses

MATH 112. Introduction to Mathematical Modeling. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Introduction for the non-specialist to mathematical modeling of real-world phenomena such as voting and networks, using graph theory, probability, and other accessible tools.

MATH 192. Topics in Calculus. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Elementary calculus and applications taken primarily from economics. Topics include algebraic, exponential, and logarithmic functions, graphs, limits, regular and partial derivatives, constrained optimization, and integration. Not open to students who have MATH 201 credit.

MATH 201. Calculus I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:4
An introduction to the calculus of algebraic, trigonometric and transcendental functions. Interpretation, significance and calculations of a derivative. Applications to geometry, biology, physics, economics, and other subjects. Introduction to the integral, including the Fundamental Theorem of Calculus and substitution. Not open to students who have MATH 192 credit.

MATH 202. Calculus II. 1 Credit.
Offered Both Fall and Spring; Lecture hours:4
Methods of integration including integration by parts, numerical approximations, and improper integrals. Sequences, series, including Taylor series. Complex numbers, polar coordinates, parametric functions, differential equations, and applications. Prerequisite: MATH 201.

MATH 203. Introduction to Mathematical Thought. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:1.5
An investigation of number, numeration, and operations from the perspective of elementary school teachers and pupils. Open only to B.S. in Education Early Childhood students. Required fieldwork.

MATH 204. Elementary Geometry and Statistics. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:1.5
Investigation of geometric, probabilistic, and statistical concepts related to elementary mathematics and how children learn and make sense of these concepts. Required fieldwork. Prerequisites: MATH 203 and permission of the instructor.

MATH 207. The Teaching of Mathematics in Secondary Schools. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:1.5
Investigation into the components of effective secondary school mathematics instruction, including lesson design/ implementation (curriculum, tasks, discourse, and assessment). Required fieldwork. Prerequisite: EDUC 201 or permission of the instructor.

MATH 208. Mathematical Explorations. .5 Credits.
Offered Fall Semester Only; Lecture hours:3
An exploration of topics from pure mathematics, applied mathematics and statistics, illustrating the power and beauty of mathematical reasoning. For students considering a major in mathematics. Corequisites: MATH 201 or MATH 202 or MATH 211 or MATH 212 or MATH 216. Open to first-year students only.

MATH 209. Mathematical Problem Solving. .5 Credits.
Offered Fall Semester Only; Lecture hours:Varies; Repeatable
Mathematical problem solving, with an emphasis on problems and topics that appear in contests such as the Putnam Competition. Prerequisite: permission of the instructor.

MATH 211. Calculus III. 1 Credit.
Offered Both Fall and Spring; Lecture hours:4
Calculus of vector-valued functions and functions of several variables. Multiple, line, and surface integrals; applications, and extrema. Green's, Stokes' and Divergence Theorems. Prerequisite: MATH 202.

MATH 212. Differential Equations. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Basic methods of solving ordinary differential equations. Systems of linear differential equations, Laplace transform, applications and selected topics. Prerequisite: MATH 211. Not open to students who have taken MATH 222.

MATH 216. Statistics I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3,Other:1
Exploratory data analysis, sampling and experimental designs, sampling distributions and confidence intervals, hypothesis testing, least squares regression, ANOVA, applications. Statistical software is used and a semester long project with real data is undertaken. Not open to students who have MATH 226, MATH 227 or PSYC 215 credit.

MATH 217. Statistics II. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3,Other:1
Exploratory data analysis, multiple linear regression, analysis of variance and logistic regression. Inferential analysis emphasizing applications to a range of disciplines is conducted using statistical software. Prerequisite: MATH 216 or equivalent. Students who have taken MATH 305 / MATH 405 need instructor's permission to enroll. Crosslisted as MATH 617.

MATH 219. Topics in Applied Mathematics. 1 Credit.
Offered Occasionally; Lecture hours:3; Repeatable
Topics such as financial mathematics, mathematical biology, cryptography, social networks, etc. Topic varies by semester. Prerequisite: varies by topic.

MATH 222. Differential Equations for Engineers. .5 Credits.
Offered Spring Semester Only; Lecture hours:3
First order differential equations, second order linear equations, higher order linear equations, numerical approximations. Prerequisite: MATH 211. Open only to civil engineering and environmental engineering students. Not open to students who have MATH 212 credit.

MATH 226. Probability and Statistics for Engineers. .5 Credits.
Offered Fall Semester Only; Lecture hours:3
Exploratory data analysis, probability theory, discrete and continuous random variables, point estimation, sampling distributions and methods of statistical inference. Statistical software is used. Prerequisite: MATH 202. Open only to engineering students and students in computer science. Not open to students who have MATH 216 credit.

MATH 227. Statistics and Engineering. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Probability theory, discrete and continuous random variables, sampling distributions and methods of statistical inference including regression and ANOVA. Software is used. Prerequisite: MATH 202. Open only to engineering students and students in computer science. Not open to students who have MATH 216 credit.

MATH 230. Data Visualization & Computing. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Simulation-based learning for concepts including sampling, sampling distributions, p-values, and confidence levels. Data visualization beyond simple exploratory data analysis techniques. Advanced statistical software will be used. Prerequisite: MATH 216 or MATH 227 or permission of the instructor.

MATH 240. Combinatorics and Graph Theory. .5 Credits.
Offered Spring Semester Only; Lecture hours:3
Counting techniques and traversal problems. Students join MATH 241 mid-semester. Pre- or co-requisite: MATH 280. Only for computer science students or students seeking secondary certification.

MATH 241. Discrete Structures. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Logic, sets; mathematical induction; relations, functions; combinatorics and graph theory. Not open to students with MATH 280 credit. Prerequisite: MATH 202.

MATH 245. Linear Algebra. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Linear equations, matrices, vector spaces, linear transformations, eigenvalues, inner products, Gram-Schmidt algorithm, singular value decomposition. Prerequisite: MATH 202.

MATH 260. Applications of Calculus to Medicine and Biology. 1 Credit.
Offered Occasionally; Lecture hours:3
Researchers in biology use mathematical models to design strategies for controlling epidemics, administering drugs, and managing ecosystems. In this class you will learn how to develop your own models, approximate solutions to your models, and compare these solutions to real data. Crosslisted as BIOL 360 or BIOL 662.

MATH 280. Logic, Sets, and Proofs. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Logic, sets; proof techniques; relations, functions, sequences and convergence; cardinality. Skills and tools for independent reading, problem solving and exploration. Prerequisite: MATH 211 or MATH 245.

MATH 291. Undergraduate Readings. .5-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Readings and research in special topics at an intermediate level. Prerequisites: permission of the instructor, adviser, and department chair.

MATH 303. Probability. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Elementary probability, random variables, moments, central limit theorem, conditional expectation, statistical distributions derived from the normal distribution. Probability simulations and applications from various fields. Prerequisite: MATH 211. Crosslisted as MATH 603.

MATH 304. Statistical Inference Theory. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Point and interval estimation, Fisher's likelihood theory, hypothesis testing, simulation techniques. R or SAS will be used. Prerequisites: MATH 216 or MATH 227, and MATH 303, or permission of the instructor. Crosslisted as MATH 604.

MATH 306. Bayesian Statistics. 1 Credit.
Offered Alternating Fall Semester; Lecture hours:3
Bayesian methods will be introduced including the ideas of prior distributions, likelihood functions, posterior distributions, prediction for common distributions and credible intervals. Advanced statistical software will be used. Prerequisites: MATH 230 and MATH 303, or permission of the instructor. Crosslisted as MATH 606.

MATH 308. Real Analysis I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Real numbers and elementary topology of Cartesian spaces, convergence, continuity, differentiation, and history of the development of analysis. Prerequisites: MATH 211, MATH 245, and MATH 280.

MATH 311. Theory of Numbers. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Classical number theory in an algebraic setting. Topics include unique factorization, diophantine equations, and linear and quadratic congruences. Advanced topics from algebraic or analytic number theory. Prerequisites: MATH 245 and MATH 280 or permission of the instructor. Crosslisted as MATH 611.

MATH 319. Topics in Advanced Mathematics. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3; Repeatable
Special topics, to be selected from algebra, analysis, geometry, statistics, applied mathematics, etc. Prerequisite varies by topic. Crosslisted as MATH 619.

MATH 320. Abstract Algebra I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Groups and rings; homomorphisms and isomorphism theorems; history of the development of algebra. Additional selected topics. Prerequisites: MATH 245 and MATH 280.

MATH 333. Topology. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Topological spaces, connectedness, compactness, continuity, separation, and countability axioms. Metric, product, function, and uniform spaces. Prerequisites: MATH 211 and MATH 280, or permission of the instructor. Crosslisted as MATH 633.

MATH 335. Geometry. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
Historical and axiomatic foundations of geometry. Euclidean and non-Euclidean geometries. Prerequisite: MATH 280 or permission of the instructor. Crosslisted as MATH 635.

MATH 342. Topics in Finance or Industry. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Possible topics include industrial mathematics, financial mathematics, genetic algorithms, simulations, and network analysis. Will also include applications to economics and the writing and presenting of a project. Prerequisites: CSCI 203, MATH 245, and MATH 303 or permission of the instructor. Crosslisted as MATH 642.

MATH 343. Numerical Analysis. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Floating point arithmetic, development of computational algorithms and error estimates for root approximation, interpolation and approximation by polynomials, numerical differentiation and integration, cubic splines, least-squares, linear systems. Lab component. Prerequisites: MATH 211, CSCI 203, and one of MATH 241, MATH 245, or MATH 280; or permission of the instructor. Crosslisted as MATH 643.

MATH 345. Advanced Linear Algebra. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Systems of linear equations, vector spaces, canonical forms for linear transformations and matrices, bilinear forms, inner product spaces, applications to such other areas as geometry, differential equations, linear programming. Prerequisites: MATH 245 and either MATH 280 or permission of the instructor. Crosslisted as MATH 645.

MATH 350. Methods in Applied Mathematics. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Techniques drawn from partial differential equations, transform methods, Fourier and complex analysis, and variational calculus. Prerequisite: junior or senior status; MATH 212 or permission of the instructor. Crosslisted as MATH 650.

MATH 354. Modern Data Analysis. 1 Credit.
Offered Alternating Fall Semester; Lecture hours:3
Advanced methods in modern data analysis. Topics may include principal component analysis, random forest, clustering and classification, unsupervised learning, splines, longitudinal data analysis, survival analysis, time series, spatial statistics, and nonparametric methods. Prerequisite: MATH 230 and MATH 245, or permission of the instructor. Crosslisted as Math 654.

MATH 358. Topics in Operations Research. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Mathematical and statistical techniques in operations research. Queueing theory. Additional topics may include simulation, forecasting, non-linear programming, inventory models. Methods and applications drawn from various fields. Prerequisite: MATH 303 or permission of the instructor. Crosslisted as MATH 658.

MATH 362. Complex Analysis. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Limits, analytic functions, integrals including contour integrals. Cauchy's Integral Theorem, entire functions and singularities. Prerequisites: MATH 211 and MATH 280, or permission of the instructor. Crosslisted as MATH 662.

MATH 378. Seminar. .5 Credits.
Offered Either Fall or Spring; Lecture hours:2; Repeatable
Seminar based on topics from algebra, analysis, topology, differential equations, statistics, or applied mathematics; topics selected according to demand or interest. Prerequisite: permission of the instructor. Crosslisted as MATH 678.

MATH 391. Reading and Research. .5-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Reading and research in various topics for qualified undergraduate students. Prerequisite: permission of the instructor.

MATH 405. Statistical Modeling. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
Regression, analysis of covariance, and logistic regression. Model diagnosis and remediation. Model selection, multicollinearity. R or SAS will be used. Prerequisites: MATH 245 and MATH 304. Crosslisted as MATH 605.

MATH 407. Statistical Design of Scientific Studies. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Sampling methods for observational studies (simple random, stratified, cluster sampling), and experimental designs (completely randomized, block, crossed, nested, and mixed designs). Estimation procedures, sample size calculations. Uses R or SAS. Prerequisite: MATH 304.

MATH 409. Real Analysis II. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Continuation of MATH 308. Integration theory and advanced topics in analysis. Prerequisite: MATH 308. Crosslisted as MATH 609.

MATH 416. Modern Applied Mathematics. 1 Credit.
Lecture hours:3
Possible topics include wavelets, harmonic analysis, computational mathematics, nonlinear dynamics, dynamical systems, scientific computing, or cryptography. Prerequisites: MATH 212 and MATH 308, or permission of the instructor. Crosslisted as MATH 616.

MATH 446. Abstract Algebra II. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Continuation of MATH 320. Advanced topics in group theory including solvable groups, field theory and Galois theory. Prerequisite: MATH 320. Crosslisted as MATH 646.

MATH 491. Reading and Research. .5-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Reading and research in various topics for qualified undergraduates or graduate students at a level appropriate for a Culminating Experience. Prerequisite: permission of the instructor, adviser, and department chair.