

MATHEMATICS AND STATISTICS (BS)

Chair: Byung-Jay Kahng, PhD

Introduction

The Department of Mathematics and Statistics strives to transmit an understanding and appreciation of mathematics: its substance, its applicability, its literature, its current directions and problems, its historical development, its human worth and values; and to promote the development of skill in the practice of mathematics. For a more detailed description of the program, faculty, facilities, academic and co-curricular opportunities please go to the Mathematics and Statistics website (<https://www.canisius.edu/academics/programs/mathematics-and-statistics>).

Qualifications

Students must maintain a 2.0 GPA in their major and a 2.0 overall average to graduate with a degree in Mathematics and Statistics. Students must have a minimum grade of C- in all courses in the major.

Advisement

All students should have an advisor in the major and should contact the department directly to have an advisor assigned if they do not already have one. Meetings with academic advisors are required prior to students receiving their PIN for course registration each semester. All majors should work closely with their advisor in discussing career expectations, choosing their major electives, developing their entire academic program and planning their co-curricular or supplemental academic experiences.

Double Majors

Students who wish to expand their educational opportunities may decide to declare a double major. The decision may be based on career goals or planned graduate studies. Before a student declares a double major, it is important to meet with the appropriate academic departments for advisement. Some double major combinations can be completed within the minimum 120 credit hour degree requirement, but in some cases additional course work may be required. In order to declare a double major, the student must complete the appropriate double major request form and get the signature of each department chairperson and the appropriate associate dean. Please note that students will receive only one degree, regardless of the number of majors they complete.

Popular double majors with mathematics are economics, computer science, education, and physics, but we have also had students double major in math and music, English, political science, philosophy, Spanish, psychology, pre-medicine, and other fields.

Minors in other DISCIPLINES

Minors provide students the opportunity to pursue additional interests but generally do not require as many courses as a major. Minors generally range from five to eight required courses. The minors page (<http://catalog.canisius.edu/undergraduate/minors>) provides a complete list of minors and provides links to each minor. Some majors and minors can be completed within the minimum 120 credit hour degree requirement, but in some cases additional coursework may be required. Students must complete the appropriate minor request form.

Curriculum

An Ignatian Foundation

All undergraduate students must complete either the Canisius Core Curriculum (<http://catalog.canisius.edu/undergraduate/academics/curricular-information/core-curriculum>) or the All-College Honors Curriculum (<http://catalog.canisius.edu/undergraduate/academics/curricular-information/all-college-honors-program>). Many schools refer to their college-wide undergraduate requirements as "general education" requirements. We believe that the core curriculum and the honors curriculum are more than a series of required classes, they provide the basis for a Jesuit education both with content and with required knowledge and skills attributes that are central to our mission.

Free Electives

Students may graduate with more but not less than 120 credit hours. Free electives are courses in addition to the Core Curriculum or Honors Curriculum and major requirements sufficient to reach the minimum of 120 credit hours required for graduation.

Major Requirements

Option A (Mathematics Major)

Code	Title	Credits
MAT 111	Calculus I	4
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 219	Linear Algebra	4
MAT 222	Differential Equations	3
or MAT 351	Probability & Statistics I	
MAT 230	Logic, Set Theory, and Proofs	4
MAT 311	Abstract Algebra	4
MAT 321	Real Analysis	4
MAT 380	Mathematics Seminar	1
MAT 381	Mathematics Seminar	1
MAT 480	Mathematics Seminar	1
Select one of the following:		3
MAT 312	Topics in Algebra	
MAT 322	Topics in Analysis	
MAT 352	Probability & Statistics II	
Select four courses from the following:		12-16
Any additional 300 or 400-level mathematics courses		
PHY 335	Mathematical Analysis for Physicists	
PHY 446	Quantum Mechanics I	
Total Credits		49-53

Option B (Mathematics with a Concentration in Another Area)

Code	Title	Credits
MAT 111	Calculus I	4
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 219	Linear Algebra	4
MAT 222	Differential Equations	3
or MAT 351	Probability & Statistics I	
MAT 230	Logic, Set Theory, and Proofs	4
MAT 311	Abstract Algebra	4

MAT 321	Real Analysis	4
MAT 380	Mathematics Seminar	1
MAT 381	Mathematics Seminar	1
MAT 480	Mathematics Seminar	1
Select one of the following:		3
MAT 312	Topics in Algebra	
MAT 322	Topics in Analysis	
MAT 352	Probability & Statistics II	
Select two of the following:		6-8
any additional 300 or 400-level mathematics courses		
PHY 335	Mathematical Analysis for Physicists	
PHY 446	Quantum Mechanics I	

Total Credits 43-45

Option C (Statistics)

Code	Title	Credits
MAT 111	Calculus I	4
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 219	Linear Algebra	4
MAT 222	Differential Equations (or 300 or 400-level mathematics course)	3
MAT 230	Logic, Set Theory, and Proofs	4
MAT 321	Real Analysis	4
MAT 322	Topics in Analysis	3-4
or MAT 311	Abstract Algebra	
MAT 351	Probability & Statistics I	3
MAT 352	Probability & Statistics II	3
MAT 380	Mathematics Seminar	1
MAT 381	Mathematics Seminar	1
MAT 480	Mathematics Seminar	1
Select three of the following:		9
MAT 341	Numerical Analysis	
MAT 353	Regression Analysis	
MAT 354	Experimental Design and Statistical Computing	
MAT 370	Topics in Statistics	

Total Credits 48-49

Major Electives

Option A

Code	Title	Credits
Select one of the following:		6
PHY 223 & PHY 224	General Physics for Physical Science Majors I and General Physics for Physical Science Majors II	
Two economics courses		

Total Credits 6

Option B

Code	Title	Credits
Select one of the following:		6
PHY 223 & PHY 224	General Physics for Physical Science Majors I and General Physics for Physical Science Majors II	
Two economics courses		

Four courses in another area approved by the Department of Mathematics and Statistics

Total Credits 6

Option C

Code	Title	Credits
Select one of the following:		6
PHY 223 & PHY 224	General Physics for Physical Science Majors I and General Physics for Physical Science Majors II	
Two economics courses		

Total Credits 6

Additional Course Considerations

Option A is designed to prepare the student for positions in which mathematical competence is sought, as well as for advanced study in graduate school.

Option B allows the student to develop expertise in another area besides mathematics. Many students combine this option with a major or minor in another department. Students interested in education can get a dual major to give them a strong background in mathematics while fulfilling the requirements of the School of Education.

Option C prepares the student for advanced work or graduate study and the many careers which utilize statistical thinking. This option, together with appropriate courses in business, constitutes a good preparation for a career in actuarial science.

Roadmap

Recommended Semester Schedule for Major Courses

Option A

Freshman

Fall	Spring
MAT 111	MAT 112
	PHY 223 (or ECO course)

Sophomore

Fall	Spring
MAT 211	MAT 219
MAT 230	MAT 222 or 351

PHY 224 (or ECO course)

Junior

Fall	Spring
MAT 311	MAT 381
MAT 321	MAT elective
MAT 380	

Senior

Fall	Spring
MAT 480	Select one of the following:
MAT elective	MAT 312
MAT elective	MAT 322
	MAT 352
	MAT elective

Option B

Freshman	
Fall	Spring
MAT 111	MAT 112
	PHY 223 (or ECO course)
Sophomore	
Fall	Spring
MAT 211	MAT 219
MAT 230	MAT 222 or 351
PHY 224 (or ECO course)	
Junior	
Fall	Spring
MAT 311	MAT 381
MAT 321	MAT elective
MAT 380	
Senior	
Fall	Spring
MAT 480	Select one of the following:
MAT elective	MAT 312
	MAT 322
	MAT 352

Option C

Freshman	
Fall	Spring
MAT 111	MAT 112
	PHY 223 (or ECO course)
Sophomore	
Fall	Spring
MAT 211	MAT 219
MAT 230	MAT 351
PHY 224 (or ECO course)	
Junior	
Fall	Spring
MAT 321	MAT 381
MAT 352	Select one of the following:
MAT 380	MAT 222
	MAT 322
	MAT elective
	Select one of the following statistics electives:
	MAT 341
	MAT 353
	MAT 354
	MAT 370
Senior	
Fall	Spring
MAT 480	Select one of the following:
MAT 311 (or MAT elective)	MAT 222
Select one of the following statistics electives:	MAT 322
MAT 341	MAT elective

MAT 353	Select one of the following statistics electives:
MAT 354	MAT 341
MAT 370	MAT 353
	MAT 354
	MAT 370

Learning Goals & Objectives

Student Learning Goal 1:

Mathematics majors will perform tasks requiring logical reasoning.

Students will:

- **Objective A:** Understand the different types of mathematical statements and how they are used, including definitions, axioms, hypotheses, conclusions, theorems, corollaries, lemmata, and conjectures;
- **Objective B:** Understand methods of proof.

Student Learning Goal 2

Mathematics majors will know the content of the fundamental fields of mathematics and can perform tasks requiring complex reasoning.

Students will:

- **Objective A:** Use basic skills to manipulate expressions;
- **Objective B:** Know the basic definitions and theorems of mathematics;
- **Objective C:** Be able to perform tasks requiring complex reasoning.

Student Learning Goal 3

Mathematics majors will advance their understanding and knowledge of mathematics and their ability to convey mathematical concepts through currently available technology.

Students will:

- **Objective A (Information Literacy):** Use the internet and/or library resources to obtain relevant information concerning historical information or mathematical content in regards to current course or project. Students will be expected to both look up sources and learn to search for their own sources;
- **Objective B (Computation):** Use computers or graphing calculators to perform labor-intensive calculations and/or create graphical displays. Programs include, but are not limited to, *Excel*, *Minitab* (or other statistical software), and *Mathematica* (or other software);
- **Objective C (Presentation):** Use technology for the purpose of elegantly presenting mathematical ideas, theories or results. Technologies include PowerPoint, Prezzi, Jing, Beamer, Latex, Word, and graphical tools.

Student Learning Goal 4

Mathematics majors will communicate mathematical ideas with precision and clarity.

Students will:

- **Objective A:** Present mathematical material in writing;
- **Objective B:** Present mathematical material orally.

Minor

Mathematics Minor

(7 courses)

Code	Title	Credits
Required Courses		
MAT 111 or MAT 115	Calculus I Calculus for Business	4
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 219	Linear Algebra	4
MAT 230	Logic, Set Theory, and Proofs	4
Restricted Electives		
Select two courses from any one of the following tracks:		6-8
Probability and Statistics:		
MAT 351	Probability & Statistics I	
MAT 352	Probability & Statistics II	
Applied Mathematics:		
MAT 222	Differential Equations	
PHY 335	Mathematical Analysis for Physicists	
MAT 341	Numerical Analysis	
MAT 342	Graph Theory	
Theoretical Mathematics:		
MAT 311	Abstract Algebra	
MAT 312	Topics in Algebra	
MAT 313	Number Theory	
MAT 321	Real Analysis	
MAT 322	Topics in Analysis	
Mathematics and Culture:		
MAT 301	History of Mathematics	
MAT 331	Geometry	
Total Credits		26-28

Courses

MAT 105 Finite Mathematics	3 Credits
Introduction to finite (non-calculus) mathematics and its applications: linear, quadratic, exponential and logarithmic functions and equations; systems of linear equations and linear programming; compound interest problems and annuities.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall & spring.	
MAT 106 Calculus for the Non-Sciences	3 Credits
Fundamentals of calculus for students in business, or social or behavioral sciences. Credit not allowed if student already has credit for MAT 109 & MAT 110; or MAT 111 or MAT 115.	
Prerequisite: MAT 105	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall & spring.	
MAT 108 Precalculus for Sciences	3 Credits
Polynomials and rational, exponential, logarithmic, and trigonometric functions. Solving equations. Graphing functions. Trigonometric identities. Credit not allowed if student already has credit for MAT 109, MAT 111, or MAT 115.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: summer.	

MAT 109 Calculus with Review I	4 Credits
For science and mathematics majors. Calculus, with topics from pre-calculus. Logarithmic and exponential functions, trigonometric functions, limits, differentiation. Credit not allowed if student already has credit for MAT 111 or MAT 115.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall.	
MAT 110 Calculus with Review II	4 Credits
Continuation of MAT 109. Differentiation, related rates, optimization problems, anti-differentiation, definite integral. Credit not allowed if student already has credit for MAT 111 or MAT 115.	
Prerequisite: MAT 109	
Offered: spring.	
MAT 111 Calculus I	4 Credits
For science and mathematics majors. Calculus of functions of single variable. Functions, limits, differentiation, continuity, graphing, logarithm, exponential and inverse trigonometric functions, related rates, optimization problems, mean value theorem, l'Hospital's rule, anti-differentiation, definite integral. Credit not allowed if student already has credit for MAT 109 and MAT 110 or for MAT 115.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall & spring.	
MAT 112 Calculus II	4 Credits
Applications of integration, integration techniques, improper integrals, sequences, series, convergence tests, Taylor's series, applications; parametric and polar curves.	
Prerequisite: minimum grade of C- in one of the following MAT 109 & MAT 110, MAT 111 or MAT 115.	
Offered: fall & spring.	
MAT 115 Calculus for Business	4 Credits
Calculus for business students. Differentiation and integration of functions of one variable. Applications, concepts, examples and problems in economics and business. Credit not allowed if student already has credit for either MAT 109 and MAT 110 or for MAT 111.	
Prerequisite: 3 1/2 years of high school mathematics.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall.	
MAT 121 Mathematics through History	3 Credits
Liberal arts mathematics course. Tracing the development of mathematical ideas globally and through history, with emphasis on problem solving techniques, quantitative thinking, and deductive reasoning.	
Prerequisite: 3 years of high school math or equivalent; sophomore standing or higher.	
Fulfills College Core: Field 7 (Mathematical Sciences), Global Awareness	
Offered: spring.	
MAT 131 Statistics for Social Sciences	3 Credits
A first course for majors in social or health sciences. Descriptive statistics, calculators, computer programs and introduction to inferential statistics. Credit not allowed if student already has credit for MAT 141 or MAT 351.	
Prerequisite: 3 years of high school mathematics or equivalent.	
Fulfills College Core: Field 7 (Mathematical Sciences)	
Offered: fall & spring.	

<p>MAT 141 Inferential Statistics and Computers for Science 4 Credits Elementary probability theory, descriptive statistics, hypothesis testing, estimation, correlation and regression. The computer will be used with one of the standard statistical packages. Credit not allowed if student already has credit for MAT 131 or MAT 351. Prerequisite: 3 1/2 years of high school mathematics. Fulfills College Core: Field 7 (Mathematical Sciences) Offered: fall & spring.</p>	<p>MAT 301 History of Mathematics 3 Credits Development and interrelations of major areas of mathematics, from ancient to modern times. Emphasis on both historical context and mathematical content. Mathematics as cultural heritage. Prerequisite: MAT 111 & MAT 112. Offered: fall of odd-numbered years.</p>
<p>MAT 150 Mathematics and Politics 3 Credits Liberal arts course emphasizing applications of math in the social sciences. Covers topics such as voting theory, decisions made by groups, measurement of political power. Prerequisite: 3 years of high school mathematics or equivalent. Fulfills College Core: Field 7 (Mathematical Sciences), Justice Offered: spring.</p>	<p>MAT 311 Abstract Algebra 4 Credits Introduction to the basic structures of abstract algebra; groups, rings, fields. Prerequisite: minimum grade of C- in both MAT 219 and MAT 230. Offered: fall.</p>
<p>MAT 161 Mathematics for Elementary Teachers 3 Credits Designed to provide a solid foundation for the mathematical topics encountered in elementary schools. The primary goal is to develop a deep understanding of mathematical concepts so future teachers can teach with knowledge and confidence. The main topics are: problem solving processes and strategies, elementary set theory, the theory behind basic arithmetic, number systems, basic probability and statistics, elementary geometry. Prerequisite: 3 years of high school mathematics or equivalent. Fulfills College Core: Field 7 (Mathematical Sciences) Offered: occasionally.</p>	<p>MAT 312 Topics in Algebra 3 Credits Continuation of MAT 311. Selected topics from groups, rings, integral domains, field extensions and Galois theory. Prerequisite: MAT 311. Offered: spring 2017.</p>
<p>MAT 191 Introduction to Discrete Mathematics 4 Credits Fundamental topics with computer science applications. Sets and logic, propositional and predicate calculus, elements of combinatorics and counting, elementary discrete probability, functions and relations, and graphs. Prerequisite: sophomore standing or instructor's permission. Offered: spring.</p>	<p>MAT 313 Number Theory 3 Credits Divisibility, prime numbers, numerical functions, congruencies, quadratic reciprocity, Diophantine equations. Prerequisite: MAT 311 or permission of instructor. Offered: occasionally.</p>
<p>MAT 211 Calculus III 4 Credits Continuation of MAT 111 and MAT 112. Analytic geometry of 3-dimensional space and calculus of functions of several variables. Prerequisite: minimum grade of C- in MAT 112. Offered: fall & spring.</p>	<p>MAT 321 Real Analysis 4 Credits Advanced study of limits, continuity, differentiation and integration of functions. Prerequisite: minimum grade of C- in MAT 211, MAT 219 & MAT 230. Offered: fall.</p>
<p>MAT 219 Linear Algebra 4 Credits Vector spaces and inner product spaces. Linear transformations and matrices. Eigenvectors, eigenvalues, and applications. Orthogonal transformations. Quadratic forms and quadric surfaces. Prerequisite: MAT 112 or permission of instructor. Offered: spring.</p>	<p>MAT 322 Topics in Analysis 3 Credits Continuation of MAT 321. Selected topics from functions of one or several variables. Prerequisite: minimum grade of C- in MAT 321. Offered: spring 2018.</p>
<p>MAT 222 Differential Equations 3 Credits Introduction to the theory and applications of ordinary differential equations. Prerequisite: minimum grade of C- in MAT 211. Offered: spring.</p>	<p>MAT 331 Geometry 3 Credits Axioms for geometry and their consequences: independence of the parallel postulate. Rudiments of hyperbolic geometry. Geometric transformations. Prerequisite: MAT 230. Offered: fall of even-numbered years.</p>
<p>MAT 230 Logic, Set Theory, and Proofs 4 Credits Transition from calculus to upper division courses: logic and methods of proof; set theory; relations, orders and functions; number systems; cardinality. Prerequisite: minimum grade of C- in MAT 112 or permission of instructor. Offered: fall.</p>	<p>MAT 341 Numerical Analysis 3 Credits The methods used to obtain numerical solutions of functional and differential equations. Polynomial interpolation. Various approximation algorithms. Prerequisite: MAT 219 & an elementary knowledge of computer programming. Offered: spring 2017.</p>
	<p>MAT 342 Graph Theory 3 Credits This course covers basic constructions on graphs. Complete graphs, bipartite graphs, trees, cycles, and more general graphs are studied along with their combinatorial properties. Euler circuits, Hamilton circuits, spanning trees. Applications of graphs to optimization problems such as the Traveling Salesperson Problem and Construction of the Minimal Spanning Trees. Prerequisite: MAT 111 or MAT 115. Offered: spring 2018.</p>

<p>MAT 345 Climate and Sustainability 3 Credits</p> <p>This course, for majors from all the sciences, develops the use of conceptual models in understanding complicated situations, while illustrating the role of scientific arguments in societal debates about climate change and sustainability. Topics include: the Earth's energy balance, historical data for ocean and atmosphere and temperature and their circulation and oscillation patterns, the carbon cycle and biological systems, and handling large data. The increasingly sophisticated examples explored in the course will introduce the use of various areas of mathematics: linear models and networks, calculus-based dynamical systems, statistics and data assessment, and analysis of periodic phenomena. Students will learn about these topics by seeing simple examples of their use. The last part of the course will center on sustainability issues, and connections to global awareness, diversity, ethics, and justice.</p> <p>Prerequisite: MAT 111 or equivalent. Restriction: seniors only. Fulfills College Core: Core Capstone Offered: occasionally.</p>	<p>MAT 370 Topics in Statistics 3 Credits</p> <p>Selected topics in applied probability and statistics, and nonparametric statistics.</p> <p>Prerequisite: MAT 352 or permission of instructor. Offered: fall 2017.</p>
<p>MAT 351 Probability & Statistics I 3 Credits</p> <p>Introduction to the mathematical aspects of modern probability theory and the theory of statistics.</p> <p>Prerequisite: MAT 211. Offered: spring.</p>	<p>MAT 380 Mathematics Seminar 1 Credit</p> <p>Mathematics seminar for majors. To be taken for three semesters.</p> <p>Prerequisite: junior standing. Offered: fall & spring.</p>
<p>MAT 352 Probability & Statistics II 3 Credits</p> <p>Continuation of MAT 351. Introduction to the mathematical aspects of modern probability theory and the theory of statistics.</p> <p>Prerequisite: MAT351. Offered: fall.</p>	<p>MAT 381 Mathematics Seminar 1 Credit</p> <p>Mathematics seminar for majors. To be taken for three semesters.</p> <p>Prerequisite: junior standing. Offered: fall & spring.</p>
<p>MAT 353 Regression Analysis 3 Credits</p> <p>Linear regression and correlation. Covariance, residual sum of squares, residual variance, correlation coefficient, tests of significance for correlation coefficient and for regression coefficients. Non-linear regression.</p> <p>Prerequisite: MAT 351 & MAT 352, or permission of instructor. Offered: spring 2017.</p>	<p>MAT 411 Topology 3 Credits</p> <p>An introduction to topology, stressing concrete examples including surfaces. Point-set, geometric and algebraic topology with interconnections and applications.</p> <p>Prerequisite: MAT 230. Offered: occasionally.</p>
<p>MAT 354 Experimental Design and Statistical Computing 3 Credits</p> <p>Analyzing data; one-way/two-way blocking; chi-square, goodness of fit. Statistical computing package; Monte-Carlo simulation-subset selection, central limit theorem; residual plots.</p> <p>Prerequisite: MAT 351 & MAT 352, or permission of instructor. Offered: spring 2018.</p>	<p>MAT 421 Complex Analysis 3 Credits</p> <p>Complex numbers, analytic functions and mappings. Cauchy-Riemann equations, harmonic functions, Cauchy's theorem, integral formula and inequalities. Power series, residues, singularities and zeros, Rouché's Theorem.</p> <p>Prerequisites: MAT 322 or PHY 335. Offered: occasionally.</p>
<p>MAT 361 Probability for Actuaries 1 Credit</p> <p>This course prepares students to take Exam P of the Society of Actuaries or Exam 1 from the Casualty Actuary Society. Key probability concepts are reviewed and students learn to apply these tools to problems encountered by actuaries. The course will develop a thorough command of calculus and probability topics. Additionally, a very basic knowledge of insurance and risk management is introduced.</p> <p>Prerequisite: MAT 211 & MAT 351. Corequisite: MAT 352 or permission of instructor. Offered: fall.</p>	<p>MAT 480 Mathematics Seminar 1 Credit</p> <p>Mathematics seminar for majors. To be taken for three semesters.</p> <p>Prerequisite: junior standing. Fulfills College Core: Oral Communication Offered: fall & spring.</p>
<p>MAT 362 Financial Mathematics for Actuaries 1 Credit</p> <p>This course prepares students to take Exam FM of the Society of Actuaries or Exam 2 from the Casualty Actuary Society. It covers interest theory (discrete and continuous) and an introduction to derivative securities.</p> <p>Prerequisite: MAT 111 & MAT 112 or permission of instructor. Offered: spring.</p>	<p>MAT 498 Internship in Mathematics 1-3 Credits</p> <p>Internship involving non-routine tasks linking academic concepts to practical experience. May be used for free elective credit only. Internships require an application and approval by the associate dean.</p> <p>Prerequisite: permission of the chair & associate dean. Offered: occasionally.</p>
	<p>MAT 499 Independent Study 1-4 Credits</p> <p>Study and work with a faculty supervisor. Project to be determined by faculty agreement. Independent studies require an application and approval by the associate dean.</p> <p>Prerequisite: permission of the instructor, department chair, & associate dean. Offered: occasionally.</p>