MATHEMATICS AND STATISTICS

Mathematics is the study of patterns, both quantitative and spatial. As such, it is the key to understanding our natural and technical world. Through the study of mathematics, students develop skills in problem solving, critical thinking and clear, concise writing. Statistics is the study of data. In a world where data is readily available and so many decisions are made from data analytics, students need to be equipped to extract meaning from data.

ABOUT THE PROGRAM

The Department of Mathematics and Statistics offers courses which serve as a fundamental part of a liberal education and as a basis for work in other disciplines. In addition, the department offers a complete major program providing opportunities for a deeper study of mathematics as well as an optional concentration in statistics. Mathematics majors pursue a wide range of career options, including work in teaching, business, industry and government service. Many mathematics majors choose to continue their studies with graduate work in mathematics, statistics, computer science or other fields which require significant mathematical background, such as economics or science.

The department also provides opportunities for independent study and research. Collaborative student/faculty research projects have been conducted in the areas of mathematical modeling, chaos theory, dynamical systems, statistics, real analysis, complex analysis, linear algebra, algebra, representation theory, geometry and bioinformatics.

Study abroad opportunities are available in Budapest, Hungary and Aberdeen, Scotland. In addition, majors can study off-campus at a variety of domestic locations such as Oak Ridge National Laboratory.

MAJORS

The Department of Mathematics and Statistics offers both a Bachelor of Science and a Bachelor of Arts in mathematics with the option for a concentration in Statistics. Many of our majors are double majors or minors in areas such as chemistry, physics, computer science and economics. We also have majors who have a second major or minor in areas such as music and English. About half of our mathematics majors become teachers. We offer a Mathematics Secondary Education Major for students intending to become middle school or high school mathematics teachers.

Bachelor of Arts Degree

The requirement for a Bachelor of Arts degree in mathematics is a plan of study designed in consultation with a departmental advisor, and includes a total of at least 34 credits in mathematics as follows:

- MA 280, 331 and 341 must be included
- Additional credits chosen from the following courses: MATH 126, 131, 132, 231, 232, and all courses numbered above 300 *except* 323 and 324
- No more than 16 credits from courses numbered 232 and lower shall be counted towards the 34 required credits

A Statistics Concentration will include MATH 311, 312, 365 and either Math 313 or 362 as part of the 34 required mathematics credits.

See individual course descriptions for prerequisites.

Bachelor of Science Degree

The requirement for a Bachelor of Science degree in mathematics is a plan of study designed in consultation with a departmental advisor, and includes a total of 60 credits of courses from the Natural and Applied Science division of which at least 39 credits must be in mathematics as follows:

- MATH 280, 331 and 341 must be included
- Additional credits chosen from the following courses: MATH 126, 131, 132, 231, 232, and all courses numbered above 300 *except* 323 and 324
- No more than 16 credits from courses numbered 232 and lower shall be counted towards the 39 required credits

A Statistics Concentration will include MATH 311, 312, 365 and either MATH 313 or 362 as part of the 39 required mathematics credits.

See individual course descriptions for prerequisites.

Mathematics Secondary Education

In partnership with the Hope College Department of Education, the Department of Mathematics and Statistics offers a teaching major in the secondary level for certification through the State of Michigan.

The requirement for a Bachelor of Arts degree in mathematics for those intending to become middle school or high school mathematics teachers is a plan of study designed in consultation with a departmental advisor, and includes a total of at least 34 credits in mathematics as follows:

- MATH 132, 231, 280, 311, 312, 321, 331, 341, and 351 must be included
- Additional credits chosen from the following courses: MATH 126 or 131, MATH 232 and all courses numbered above 300 *except* 323 and 324
- No more than 16 credits from courses numbered 232 and lower shall be counted towards the 34 required credits

- MATH 323 and 324 must also be taken (*this counts as education credit, and does not count toward the 34 mathematics credits*).

MINORS

The Department of Mathematics and Statistics offers a Minor in Mathematics and a Minor in Statistics for non-mathematics majors. We also offer a Mathematics Secondary Education Minor for students intending to become middle school or high school teachers.

Mathematics

A minor in mathematics consists of at least 19 credits from the following courses: MATH 126, 131, 132, 231, 232, 280, and all courses numbered above 300 except 323 and 324. No more than 16 credits from courses numbered 232 and lower shall be counted towards the 19 required credits.

Note: For students desiring an applied focus to their minor (e.g., actuarial studies, statistics, mathematical biology, mathematical modeling, etc.) recommended courses include:

- Calculus (MATH 126, 131, 132, 231, 232)
- Statistics (MATH 311/312)
- Probability (MATH 365/366)
- Linear Algebra (MATH 345)
- Differential Equations (MATH 370)
- Numerical Analysis (MATH 372)

For more specific recommendations for your proposed career, speak with your advisor or a member of the Department of Mathematics.

Mathematics Secondary Education

In partnership with the Hope College Department of Education, the Department of Mathematics and Statistics offers a teaching minor in the secondary level for certification through the State of Michigan.

The requirement for a minor in mathematics for those intending to become middle school or high school mathematics teachers is a plan of study designed in consultation with a departmental advisor, and includes a total of at least 24 credits in mathematics as follows:

- MATH 132, 231, 280, 311, 312, 321, and 351 must be included
- Additional credits chosen from the following courses: MATH 126 or 131, MATH 232, and all courses numbered above 300 *except* 323 and 324
- No more than 16 credits from courses numbered 232 and lower shall be counted towards the 24 required credits

- MATH 323 and 324 must also be taken (*this counts as education credit and does not count toward the 24 mathematics credits*)

Statistics

A minor in statistics is available for Non-mathematics majors and consists of at least 19 credits. The following 13 credits are required courses: MATH 132, MATH 311, MATH 312, MATH 365 and one of either MATH 313 or MATH 362.

The remaining 6 credits must be chosen from:

- MATH 131 or MATH 126
- MATH 313 (if not used above)
- MATH 362 (if not used above)
- MATH 366
- MATH 490 Independent Studies (1 cr each) for other Society of Actuaries (SOA) exam preparation
- Programming courses (from Computer Science)
- Data Science courses (from Math/Computer Science)
- other departments' research methods/statistics courses (e.g. COMM 280 Research Methods, PSY 200 Research Methods, ECON 306 Econometrics, SOC 262 Methods of Social Research, KIN 250 Research Methods in Kinesiology)

Note: a student cannot receive credit for both MA 123 and MA 125, or MA 126 and MA 131.

COURSES

MATHEMATICS

MATH 123 - A Study of Functions

A study of functions including polynomial, rational, exponential, logarithmic, and trigonometric functions. These will be explored in their symbolic, numerical, and graphic representations, and connections between each of these representations will be made. A graphing calculator is required. Cannot receive credit for both Math 123 and Math 125.

Credits Awarded: 4
Terms Offered: Spring
Attribute: Mathematics II (MA2)

MATH 125 - Calculus with Review I

This course covers the material typically taught in the first half of a Calculus I course. The calculus material is supplemented by reviewing topics of high school mathematics as needed. The calculus topics are also taught at a slower pace. Topics include function review, limits and continuity, the concept (and definition) of a derivative, and differentiation rules (product rule, quotient rule, chain rule are included). Cannot receive credit for both Math 125 and Math 123.

Credits Awarded: 4
Terms Offered: Fall
Attribute: Mathematics II (MA2)

MATH 126 - Calculus with Review II

This course is a continuation of Math 125. The topics covered are the topics typically taught in the second half of a Calculus I course. The calculus material in the course is supplemented by reviewing topics of high school mathematics as needed. The calculus topics are also taught at a slower pace. Topics include implicit differentiation, applications of differentiation, L'Hospital's rule, Newton's method, the integral, and applications of integration. Cannot receive credit for both Math 126 and Math 131.

Credits Awarded: 4
Terms Offered: Spring
Prerequisites: Math 125 with grade of C- or better
Attribute: Mathematics II (MA2)

MATH 131 - Calculus I

Topics include functions, limits, continuity, differentiation, integration, and applications of the derivative and integral. Cannot receive credit for both Math 131 and Math 126. ACT Math score of 25+ is highly recommended.

Credits Awarded: 4
Terms Offered: Fall, Spring
Attribute: Mathematics II (MA2)

MATH 132 - Calculus II

Topics covered include techniques of integration, applications of the integration, sequences, infinite series, power series, introduction to differential equations, and polar coordinates.

Credits Awarded: 4
Terms Offered: Fall, Spring
Prerequisites: Math 126 or Math 131 with a grade of C- or better
Attribute: Mathematics II (MA2)

MATH 195 - Studies in Mathematics

A course offered in response to student interest and need. Covers mathematical topics not included in regular courses.

Prerequisites: Permission of instructor

Credits Awarded: 1-4
Terms Offered: Fall, Spring
Prerequisites: Permission of Instructor

MATH 205 - Mathematics for Elementary and Middle School Teachers I

The first of a two-course sequence in which prospective K-8 teachers explore the fundamental aspects of the mathematics they will be expected to teach in their future classrooms. Emphasis is on developing a conceptual understanding of the mathematics and the ability to communicate mathematical concepts effectively to K-8 students. Topics addressed: Number Concepts and Operations; Algebraic Thinking, Statistics & Probability. Proficiency in basic mathematical skills is assumed. For prospective elementary and middle school teachers only. Completion of, or concurrent enrollment in, an Educ 200-level course is highly recommended prior to this course.

Credits Awarded: 4
Terms Offered: Fall
Prerequisites: Educ 220 and Educ 221
Attribute: Mathematics II (MA2)

MATH 206 - Mathematics for Elementary and Middle School Teachers II

A continuation of Math 205 with a focus on geometry and measurement. For prospective elementary and middle school teachers only.

Credits Awarded: 2
Terms Offered: Spring
Prerequisites: Math 205 with a grade of C- of better
Attribute: Mathematics II (MA2)

MATH 210 - Introductory Statistics

The course begins by exploring statistical inference for one and two variables using a randomization approach, while reviewing basic descriptive statistical techniques. The course then explores the relationship between randomization methods and traditional inference techniques, estimation using confidence intervals and statistical power and its impact on sample design decisions. Throughout the course there is an emphasis on active-learning using group activities and projects, as well as reading and critiquing research from mainstream and peer-reviewed media sources. Activities, projects and hands-on learning activities are conducted using a variety of approaches but make heavy use of the computer and statistical software. Cannot receive credit for both Math 210 and Math 311.

Credits Awarded: 4
Terms Offered: Fall, Spring
Attribute: Mathematics II (MA2)

MATH 221 - Introduction to Mathematics for Elementary Educators

The first in a three-course sequence in which prospective elementary (Pre-Kindergarten to 6th Grade) teachers explore the fundamental aspects of the mathematics they will be expected to teach. Emphasis is on developing a deep conceptual understanding of the specialized mathematical content knowledge and the methods to communicate mathematical concepts effectively to children expected of well-prepared beginning teachers. Topics addressed: How children learn mathematics, Number Concepts, and Properties of Shapes and Spatial Relationships. Proficiency in basic mathematical skills is assumed. For prospective elementary and special education teachers only.

Credits Awarded: 4
Terms Offered: Fall, Spring
Prerequisites: Declared education major

MATH 223 - Mathematics for Elementary Educators

The second course in a three-course sequence in which prospective elementary teachers explore the fundamental aspects of the mathematics they will be expected to teach. Emphasis is on developing a deep conceptual understanding of the specialized mathematical content knowledge and the methods to communicate mathematical concepts effectively to children expected of well-prepared beginning teachers. Topics addressed: Mathematical Development in Children, Additive Reasoning, Multiplicative Reasoning, and Early Fraction Concepts. For prospective elementary education and special education teachers only.

Credits Awarded: 4
Terms Offered: Fall, Spring
Prerequisites: Declared education major, Math 221 with a grade of C+ or better

MATH 231 - Multivariable Mathematics I

The study of linear algebra and ordinary differential equations.

Credits Awarded: 4
Terms Offered: Fall, Spring
Prerequisites: Math 132 with a grade of C- or better
Attribute: Mathematics II (MA2)

MATH 232 - Multivariable Mathematics II

The study of systems of differential equations and multivariable calculus including differentiation, multiple integration, and calculus on vector fields.

Credits Awarded: 4
Terms Offered: Fall, Spring
Prerequisites: Math 231 with a grade of C- or better
Attribute: Mathematics II (MA2)

MATH 280 - Bridge to Higher Mathematics: An Introduction to Mathematical Proof

An introduction to the understanding and creation of rigorous mathematical argument and proof. Topics include properties of the integers, real numbers, and integers modulo n. Additional topics may include mathematical induction, elementary set theory, elementary number theory, recursion formulas, counting techniques, equivalence relations, partitions and cardinality of sets. There will be a heavy emphasis on writing, in particular the writing of mathematical arguments and proofs.

Credits Awarded: 3
Terms Offered: Spring
Prerequisites: Math 132

MATH 295 - Studies in Mathematics

A course offered in response to student interest and need. Covers mathematical topics not included in regular courses.

Credits Awarded: 1-4
Terms Offered: Fall, Spring
Prerequisites: Permission of instructor

MATH 308 - Mathematical Teaching Practices for Elementary Educators

The final course in a three-course sequence in which prospective elementary teachers explore the fundamental aspects of the mathematics they will be expected to teach. Emphasis is the development of content specific teaching practices, techniques and dispositions that support sound mathematical teaching. Pre-service teachers learn to value and encourage the development of children's strategies and invented algorithms within the context of mathematical operations with fractions. Students will engage in practice-based explorations of effective teaching and high-leverage practices in mathematics using materials taken from real classrooms. For prospective elementary teachers only.

Credits Awarded: 2
Terms Offered: Fall, Spring
Prerequisites: Declared education major, Math 223 with a grade of C+ or better

MATH 311 - Statistical Methods

This course has the same content and learning objectives as Math 210 but the material is covered in half the time. The course is designed for students who have a significant prior experience with statistics (e.g., high school statistics course) or calculus. Read the Math 210 course description for course content details. Cannot receive credit for both Math 210 and Math 311.

Credits Awarded: 2
Terms Offered: Spring
Prerequisites: Math 131 or statistics transfer credit
Attribute: Mathematics II (MA2)

MATH 312 - Applied Statistical Models

This course provides a survey of statistical methods students would expect to see utilized across disciplines in peer reviewed research. As such, the course focuses on the design and analysis of studies where the research questions involve more than two variables simultaneously. Topics include multiple and non-linear regression, non-parametric methods, general linear models, and multivariate statistical models. The pedagogical approach is similar to that of Math 210 and Math 311.

Credits Awarded: 2
Terms Offered: Spring
Prerequisites: Math 210 or Math 311
Attribute: Mathematics II (MA2)

MATH 313 - Statistical Methods III

Recent advances in Data Science have resulted in the introduction of many new methods in Applied Statistics. This course focuses on the application of some of these new methods in two of the main branches of Data Science - Prediction (supervised learning) and Classification (unsupervised learning).

Credits Awarded: 3
Terms Offered: Fall
Prerequisites: Math 312

MATH 318 - Mathematical Biology

An exploration of the ways in which mathematics is used to understand and model biological systems. Using examples from ecology, neuroscience, epidemiology, and molecular evolution, we will focus on continuous and discrete models and their analytical and computational solutions. Systems of differential equations, linear algebra, and statistical methods will figure prominently among the mathematical topics. Students will become familiar with the statistical, graphical & modeling capabilities of the R computer language. Cross-listed with Biol 318.

Credits Awarded: 4
Terms Offered: Spring, Odd years
Prerequisites: Biol 105 and Biol 106, Biol 107 or equivalent, Or, Math 231

MATH 321 - History of Mathematics

This course is designed to give mathematics students an opportunity to study the various periods of mathematical development. Attention will be given to the early Egyptian-Babylonian period, the geometry of Greek mathematicians, the Hindu and Arabian contribution, the evolvement of analytical geometry since Descartes, the development of calculus by Newton and Leibniz, and non-Euclidean geometry. Some attention will be given to the methods and symbolisms used in problem solving during various periods of time.

Credits Awarded: 2
Terms Offered: Fall
Prerequisites: Math 132

MATH 323 - Teaching of Mathematics in the Secondary School

Methods of teaching mathematics with emphasis on varied approaches, classroom materials, curriculum changes, and trends in mathematics education. Cross-listed as Educ 323.

Credits Awarded: 3
Terms Offered: Fall
Prerequisites: Declared education major
Corequisites: Math 324

MATH 324 - Teaching Mathematics in the Secondary School Field Placement

This is a field placement that must be taken concurrently with Math 323.

Credit Awarded: 1
Terms Offered: Fall
Prerequisites: Declared education major
Corequisites: Math 323

MATH 331 - Real Analysis I

Study of the real number system, sequences, functions, continuity, uniform continuity, differentiation, and theory of integration.

Credits Awarded: 3
Terms Offered: Fall
Prerequisites: Math 232, Math 280

MATH 332 - Real Analysis II

A continuation of Math 331 including functions of several variables, series, uniform convergence, Fourier Series.

Credits Awarded: 3
Terms Offered: Spring, Even Years
Prerequisites: Math 331

MATH 334 - Complex Analysis

The study of the algebra and geometry of complex numbers, analytic functions, complex integration, series, conformal mapping.

Credits Awarded: 3
Terms Offered: Fall, Odd Years
Prerequisites: Math 232

MATH 341 - Algebraic Structures I

An introduction to algebraic systems including a study of groups, rings, and integral domains.

Credits Awarded: 3
Terms Offered: Fall
Prerequisites: Math 232, Math 280

MATH 342 - Algebraic Structures II

A continuation of Math 341 including topics chosen from Galois theory, advanced linear algebra, group representation theory, and algebraic geometry.

Credits Awarded: 3
Terms Offered: Spring, Odd Years
Prerequisites: Math 341

MATH 345 - Linear Algebra

The study of abstract vector spaces, matrices and linear transformations, determinants, canonical forms, the Hamilton-Cayley theorem, inner product spaces.

Credits Awarded: 3
Terms Offered: Spring, Even Years
Prerequisites: Math 231, Math 280

MATH 351 - College Geometry

A modern approach to geometry for students with some background in calculus and an interest in secondary teaching. Attention is given to the role of axioms in elementary geometry and in the development of other geometries.

Credits Awarded: 3
Terms Offered: Fall
Prerequisites: Math 280

MATH 360 - Combinatorics and Graph Theory

A study of topics in discrete mathematics. Topics may include enumeration, algorithms, graph theory, graph planarity, graph coloring, the pigeonhole principle, permuatations and combinations, binomial coefficients, search algorithms, generating functions, and recurrence relations.

Credits Awarded: 3
Terms Offered: Spring, Odd Years
Prerequisites: Math 280

MATH 362 - Mathematical Statistics

Emphasis on inferential statistics. Estimation, confidence intervals, testing of statistical hypotheses, regression and correlation, analysis of variance, control charts, non-parametric methods.

Credits Awarded: 3
Terms Offered: As Needed
Prerequisites: Math 361 or Math 365

MATH 364 - Laboratory for Mathematical Statistics

A computer-based laboratory to aid the learning and understanding of statistical concepts in Math 362.

Credit Awarded: 1
Terms Offered: As needed
Prerequisites: Math 361 or Math 365

MATH 365 - Introduction to Probability

This course provides an introduction to both discrete and continuous probability. Topics include conditional probabilities and independence, combinations and permutations, Bayes' theorem, popular discrete and continuous distributions, bivariate and multivariate distributions, covariance and correlation, moment generating functions. This course serves as a general introduction to probability for all students interested in applied mathematics.

Credits Awarded: 2
Terms Offered: Fall, Even Years
Prerequisites: Math 132

MATH 366 - Probability for Actuaries

This course runs in the second half of the fall semester of even years after Math 365 and serves as an opportunity to prepare interested students for the Society of Actuaries' Probability Exam (Exam P) as well as delve deeper into the Introduction to Probability course. Students may take Math 365 either prior to enrollment in or concurrently with the class.

Credits Awarded: 2
Terms Offered: Fall, Even Years
Prerequisites: Math 365
Corequisites: Math 365

MATH 370 - Advanced Differential Equations

Advanced topics in ordinary differential equations including series solutions and orthonormal sets of solutions. Introduction to partial differential equations including the heat equation, the wave equation and the potential equation. Boundary value problems and Fourier Series will also be covered.

Credits Awarded: 3
Terms Offered: Spring, Odd Years
Prerequisites: Math 232

MATH 372 - Numerical Analysis

Topics may include the study of the source and analysis of computational error, finding the solution of an equation, systems of linear equations, interpolation and approximation, numerical integration and numerical solutions to differential equations.

Credits Awarded: 3
Terms Offered: Spring, Even Years
Prerequisites: Math 232

MATH 395 - Special Studies in Mathematics

A course offered in response to student and instructor interest. Topics are not generally covered in the regular course listings. Course may be taken multiple times if topics are different.

Credits Awarded: 1-4
Terms Offered: As Needed

MATH 399 - Mathematics Seminar

A course for senior mathematics majors which includes problem solving, student presentations on mathematical topics, mathematical modelling, and discussions on the history and philosophy of mathematics. Attendance at department colloquia also required.

Credits Awarded: 2
Terms Offered: As Needed

MATH 434 - Elementary Topology

A systematic survey of the standard topics of general topology with emphasis on the space of real numbers. Includes set theory, topological spaces, metric spaces, compactness, connectedness, and product spaces. Students may take Math 331 either prior to enrollment in or concurrently with the class.

Credits Awarded: 3
Terms Offered: As Needed
Prerequisites: Math 331
Corequisites: Math 331

MATH 490 - Research in Mathematics

Course provides opportunity for a junior or senior mathematics major to engage in a research project in an area of mathematics in which the student has special interest.

Credits Awarded: 0-4
Terms Offered: Fall, Spring
Prerequisites: Permission of chairperson

MATH 493 - Independent Study in Mathematics

Course provides opportunity for a junior or senior mathematics major to engage in an independent study project in an area of mathematics in which the student has special interest.

Credits Awarded: 1-4
Terms Offered: Fall, Spring
Prerequisites: Permission of instructor

MATH 495 - Advanced Studies in Mathematics

Offered as needed to cover topics not usually included in the other mathematics courses. A student may enroll for either or both semesters.

Credits Awarded: 1-3
Terms Offered: Fall, Spring
Prerequisites: Permission of chairperson

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