Mathematics

Professors: Barth, Gandini, Intermont, Nguyen, Nordmoe (Chair), Ollo

The mission of the Mathematics Program is to foster in all our students critical habits of mind: description, analysis and interpretation. The Program is designed to prepare its majors for successful lifetime engagement with mathematics whether it be through applied work in industry or government; research in mathematics, statistics, or one of the other mathematical sciences; teaching; or applying mathematics in the physical, computing, or social sciences. For non-majors, the Program builds substantive skills in quantitative and abstract reasoning and in their application to the study of modern society.

Advanced Placement

For purposes of course placement and prerequisites, a score of 4 or 5 on the AB calculus exam (or an AB subscore of the BC calculus exam) is regarded as equivalent to successful completion of MATH 112. A score of 4 or 5 on the BC calculus exam is equivalent to MATH 113. A score of 4 or 5 on the statistics exam is equivalent to MATH 260.

Transfer, Dual Enrollment, Study Abroad Credit

Courses taken at other institutions will be awarded credit in mathematics if they meet one of the following criteria:

1. The course is similar in content and rigor to an existing course in the Mathematics Department (and there are legitimate reasons why the student is not able to take the class at the College)
2. The course covers some important topic of mathematics not offered at Kalamazoo College.

Students are responsible for meeting with the department chair in advance to determine whether a course offered elsewhere will transfer back as a mathematics credit.

Requirements for the Major in Mathematics

Number of Units
Nine units of mathematics are required, exclusive of SIP and CS Cognate. Typically up to two units from outside courses (AP, transfer, dual enrollment, or study abroad) may count towards the major or minor in mathematics. MATH 205, MATH 260 and MATH 261 do not count for the major. Students who wish to apply additional external units toward the major must consult with the department.

Required Courses
MATH 112-113 Calculus I and II
MATH 214 Calculus III
MATH 240 Linear Algebra and Vectors
MATH 310 Complex and Vector Variables, MATH 316 Topics in Number Theory or MATH 318 Topics in Topology
MATH 320 Real Analysis I or MATH 330 Abstract Algebra I
One two-term sequence beyond calculus (e.g., Real Analysis I and II, Abstract Algebra I and II, Probability and Mathematical Statistics)

Required Cognate
One computer science course or one applied statistics course (MATH 260 or MATH 261)

Major Guidance
Among the courses we offer, MATH 320 and MATH 330 are at the highest level of abstraction. Before enrolling in one of these courses, students are strongly encouraged to complete MATH 310, MATH 316 or MATH318.
For students interested in graduate work in one of the mathematical sciences, additional work in MATH 280, 310, 314, 316, 320, 330, 420, 430, and 450 is appropriate. Those with a strong interest in computing should elect the minor in computer science in addition to MATH 300. For those students interested in applied work (mathematical biology, mathematical economics, operations research, etc.), election of MATH 270, 280, 310, 362, 365, 440, and at least two courses in computer science is appropriate. Other departments offer classes that use mathematical ideas: BIOL 112, 426, and 436; CHEM 310 and 410; ECON 305 and 412; PHIL 107; PHYS 340, 400, 410, and 420; and PSYC 390.

**Mathematics Colloquium Credit**

In addition to the requirements stated above, mathematics majors are required to complete the Mathematics Colloquium requirement. See the Mathematics Department for details.

**Comprehensive Exams**

Mathematics majors are required to satisfactorily complete the Sophomore Comprehensive exam and the Senior Comprehensive Exam. See the Mathematics Department for details.

**Requirements for the Minor in Mathematics**

There are four options for the minor in mathematics, each of which requires six units of credit in mathematics. Each of these options requires the "core" courses: Single variable calculus (MATH 112 and MATH 113), Multivariable Calculus (MATH 214), and Linear Algebra (MATH 240). The other required courses for each option are as follows:

**Statistics Option**
- MATH 362 Probability
- MATH 365 Mathematical Statistics

**Computational Mathematics Option**
- MATH 250 Discrete Mathematics or MATH 330 Abstract Algebra I
- MATH 300 Automata, Formal Languages, and Computability

**Applied Mathematics Option**
- MATH 280 Differential Equations
- MATH 310 Complex and Vector Variables

**Pure Mathematics Option**
- MATH 320 Real Analysis I or MATH 330 Abstract Algebra I
- And one other mathematics course from the following list:
  - MATH 310, MATH 314, MATH 316, MATH 318, MATH 320, MATH 330, MATH 362, or any 400-level course in Mathematics

**Note:** MATH-260 and MATH-261 do not count for the Mathematics minor**

**Study Abroad**

Students interested in mathematics are especially encouraged to consider the study abroad program in Budapest. The Budapest program is given in English; no prior knowledge of Hungarian is needed. It offers a number of mathematics courses as well as history, language, and literature courses. Mathematics majors have also studied mathematics in Erlangen, Quito, Perth, Aberdeen, and Lancaster. Early consultation with the department is strongly urged.

**Mathematics courses**

**MATH 105 Quantitative Reasoning and Statistical Analysis**

An introduction to some of the quantitative techniques used to clarify ordinary experience and to some of the statistical ideas used to shape public policy and human sciences, with emphasis on the concepts involved in producing, organizing, and
drawing conclusions from data. Does not count toward the major or minor. Not open to students who already have credit from ANSO-212, MATH-260, or MATH-261.

**MATH 110 Calculus I with Review, Part 1**
MATH 110 and 111 cover in two terms the material covered in Mathematics 112. In addition, topics from precalculus mathematics are reviewed and practiced as needed. Precalculus topics include: algebra and analytic geometry; linear, quadratic, polynomial and rational functions; and trigonometric functions. Enrollment is restricted to those who were advised to take Math 110-111 on the basis of the department's placement examination. The Successful completion of the two-term Math 110-111 sequence serves as an alternate prerequisite for all college courses requiring MATH 112 and contributes one unit toward the nine units required for the math major.

*Prerequisite: Placement into MATH-110 required*

**MATH 111 Calculus I with Review, Part 2**
This course continues the study of calculus begun in MATH 110. Review of precalculus mathematics continues as needed. Successful completion of the two-term Math 110-111 sequence serves as an alternate prerequisite for all college courses requiring MATH 112 and contributes one unit toward the nine units required for the math major.

*Prerequisite: MATH-110 All course prerequisites must be met with a minimum grade of C-.*

**MATH 112 Calculus I**

*Prerequisite: Math Placement Exam Required*

**MATH 113 Calculus II**
Integral calculus of single-variable functions: the fundamental theorem of calculus, techniques of integration, infinite sequences and series. An emphasis on problem solving using the tools of integral calculus with application to the natural and social sciences.

*Prerequisite: MATH-112 or MATH-111 or placement into MATH-113 All course prerequisites must be met with a minimum grade of C-.*

**MATH 214 Calculus III**
Series, vectors in two and three dimensions, and integral and differential calculus of functions of several variables.

*Prerequisite: MATH-113 or placement into MATH-214 All course prerequisites must be met with a minimum grade of C-.*

**MATH 240 Linear Algebra and Vectors**
Study of vector spaces, matrices, determinants, linear transformations, systems of equations and eigenvalues.

*Prerequisite: MATH-113 or placement into MATH-240 All course prerequisites must be met with a minimum grade of C-.*

**MATH 250 Discrete Mathematics**
Introduction to formal structures and mathematical reasoning. Graphs, sets, logic, induction, structure of mathematical proof, counting, relations, and algebraic structures.

*Prerequisite: MATH-112 and one computer science course. All course prerequisites must be met with a minimum grade of C-.*

**MATH 260 Applied Statistics I**
Introduction to statistics including methods of data collection and description, correlation and regression, chance, and statistical inference. The course makes extensive use of technology and is designed for students in the behavioral, biological, and social sciences. Does not count towards the major or minor in mathematics. Not open to students who already have credit from MATH-261.

**MATH 261 Biostatistics**
Introduction to statistics with particular attention to applications in biology and health sciences. Topics include sampling methods, design of experiments, exploratory data analysis, estimation, tests of significance, ANOVA, and correlation and regression analysis. BIOL 112 and 123 highly recommended. Does not count towards the major or minor in mathematics. Not open to students who already have credit from MATH-260.

**MATH/PHYS 270 Nonlinear Dynamics and Chaos**
Dynamical systems are mathematical objects used to model phenomena of natural and social phenomena whose state changes over time. Nonlinear dynamical systems are able to show complicated temporal, spatial, and spatiotemporal behavior. They include oscillatory and chaotic behaviors and spatial structures including fractals. Students will learn the basic mathematical concepts and methods used to describe dynamical systems. Applications will cover many scientific disciplines, including physics, chemistry, biology, economics, and other social sciences. Appropriate for Math or Physics Majors. Either MATH 305 or this course, but not both, may be counted towards the major in mathematics.

**MATH 280 Ordinary Differential Equation: Analytic, Symbolic, and Numeric Techniques**
Introduction to key concepts underlying analytical methods for the solution of ordinary differential equations and first-order
systems studied together with techniques for constructing approximate numerical solutions.

Prerequisite: MATH-214 and MATH-240 All course prerequisites must be met with a minimum grade of C-.

MATH 295 ST: Introduction to Data Science
Living under the data deluge of the early 21st century, our challenge is no longer finding data, but instead transforming it into a format useful for addressing important questions. To that end, this course will focus on the use of the R statistics language and environment to access, visualize, transform and model data. Specific topics may include data scraping, data wrangling, graphical displays, reproducible research reports, and methods for modeling data including supervised and unsupervised learning.

Prerequisite: MATH-260 or MATH-261 or COMP-210 or with instructor permission.

MATH 295 Getting to X: Math & Some of Its History
This is a course about mathematics, rather than about a branch of mathematics. We will use history as a unifying approach as we navigate ideas, in an attempt to see mathematics more broadly than our other courses usually allow. We will strive to put some of the ideas we've already encountered in context as well as introduce ourselves to new mathematical ideas.

Prerequisite: MATH-214 and MATH-240. All course prerequisites must be met with a minimum grade of C-.

MATH/COMP 300 Automata, Formal Languages, and Computability
Study of automata as mathematical models of computation; of formal languages, which play a central role in the specification and translation of programming languages; and of the fundamental capabilities and limitations of computers.

Prerequisite: MATH-250 or MATH-330, and 1 COMP course All course prerequisites must be met with a minimum grade of C-.

MATH/IDSY 305/PHYS 482 Dynamic Models in Social Science
The study of why mathematical and computational methods are important in understanding social phenomena, and how different social phenomena can be described by proper mathematical models. Specifically, applications of the theory of dynamical systems will be presented. Designed for math/science and social science students. Either MATH/PHYS 270 or this course, but not both, may be counted towards the major in mathematics.

Prerequisite: MATH-113 All course prerequisites must be met with a minimum grade of C-.

MATH 310 Complex and Vector Variables
Generalizations of differentiation and integration to spaces of higher dimension: divergence, curl, and the classical integration theorems of multivariable calculus. Introduction to analytic functions of a complex variable, including Laurent series, Cauchy's formula, and conformal mapping.

Prerequisite: MATH-214 and MATH-240 All course prerequisites must be met with a minimum grade of C-.

MATH 316 Topics in Number Theory
Study of classical number theory including distribution of primes, congruences, the Euler Phi function, and quadratic reciprocity. This course will also focus on developing proof writing skills.

Prerequisite: MATH-214 and MATH-240 with a C- or better

MATH 318 Topics in Topology
An introduction to topological spaces including the study of connectedness, metric spaces, and compactness. This course will also focus on developing proof writing skills.

Prerequisite: MATH-214 and MATH-240; All course prerequisites must be met with a minimum grade of C-.

MATH 320 Real Analysis I
Introduction to basic topological concepts in metric spaces followed by rigorous development of classical real analysis including sequences and series of functions, continuity, differentiability, and Reimann-Stieltjes integration. This course is among the most theoretical in our curriculum.

Prerequisite: MATH-310, MATH-316, or MATH-318 All course prerequisites must be met with a minimum grade of C-.

MATH 330 Abstract Algebra I
Study of modern abstract algebra including groups, rings, fields, and other algebraic structures together with advanced topics of linear algebra. This course is among the most theoretical in our curriculum.

Prerequisite: MATH-310, MATH-316, or MATH-318 All course prerequisites must be met with a minimum grade of C-.

MATH 360 Applied Statistics II
This course uses real data case studies to review descriptive statistics and to explore statistical inference for means, proportions, and transformations; analysis of variance; and regression. Statistical software is used throughout. The course is recommended both for students planning to do graduate coursework in the behavioral, biological, and social sciences and for mathematics majors seeking a comprehensive introduction to statistical methods.

Prerequisite: 200-level math course. All course prerequisites must be met with a minimum grade of C-.

MATH 362 Probability
Study of mathematical theory of probability. Topics include data analysis, discrete and continuous sample spaces,
combinatorial problems, random variables, probability densities and distributions, expected value, moment-generating functions, functions of a random variable, sampling distributions, and the central limit theorem.

Prerequisite: MATH-113 All course prerequisites must be met with a minimum grade of C-.

MATH 365 Mathematical Statistics
Study of statistical inference. Topics include sampling theory, point and interval estimations, hypothesis testing, and regression. Stochastic processes, analysis of variance, simple experimental design, and nonparametric statistics may also be included.

Prerequisite: MATH-362 All course prerequisites must be met with a minimum grade of C-.

MATH 395 Self-Selected Topics in Math
This seminar aims to develop proficiency in communicating mathematics and to provide an opportunity for students to learn about a topic of individual interest outside the usual curriculum.

MATH 420 Real Analysis II
Continuation of MATH 320.

Prerequisite: MATH-320 All course prerequisites must be met with a minimum grade of C-.

MATH 430 Abstract Algebra II
Continuation of MATH 330.

Prerequisite: MATH-330 All course prerequisites must be met with a minimum grade of C-.

MATH 450 Topics in Pure and Applied Mathematics
Readings in pure and applied mathematics. Content varies from year to year. Possible topics include: set theory, number theory, geometry, topology.

Prerequisite: 1 COMP course and MATH-250 or MATH-316 or MATH-330 All course prerequisites must be met with a minimum grade of C-.

MATH 450/COMP 483 Special Topics: Cryptography
This course provides a mathematics-based introduction to cryptography. Students will study the algorithms and security of various symmetric-key and public-key cryptosystems, and will write programs to implement several different cryptographic algorithms. Students will also gain some awareness of the social, ethical, and political issues related to cryptography.

Prerequisite: COMP-108 or COMP-110 and MATH-250 or MATH-316 or MATH-330 All course prerequisites must be met with a minimum grade of C-.

MATH 490 Senior Seminar
In this course we will explore some of the meta-themes of mathematics. In particular, we will examine how themes such as continuity and approximation are evident - or not - in various branches of mathematics. We will also reflect on such topics as the role of proof in mathematics versus the role of intuition, and what literacy in mathematics means.

MATH 593 Senior Integrated Project
Each program or department sets its own requirements for Senior Integrated Projects done in that department, including the range of acceptable projects, the required background of students doing projects, the format of the SIP, and the expected scope and depth of projects. See the Kalamazoo Curriculum -&gt; Senior Integrated Project section of the Academic Catalog for more details.

Prerequisite: Permission of department and SIP supervisor required.

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This content was last updated on October 12 2021.