MATHEMATICS AND COMPUTER SCIENCE

FACULTY

Alex Wilce, Ph.D., Associate Professor of Mathematics & Computer Science, department head
Ken Brakke, Ph.D., Professor of Mathematics & Computer Science
Edisanter Lo, Ph.D., Professor of Mathematics & Computer Science
Jeffrey A. Graham, Ph.D., Associate Professor of Mathematics & Computer Science
Hojin Chang, D.Sc., Assistant Professor of Mathematics & Computer Science
Alathea Jensen, Ph.D., Assistant Professor of Mathematics & Computer Science
Zachary Scherr, Ph.D., Assistant Professor of Mathematics & Computer Science (on leave Fall 2021 and Spring 2022)
Joy Azzam, Ph.D., Visiting Assistant Professor of Mathematics & Computer Science

MATHEMATICS

LEARNING GOALS:

- Students acquire sufficient knowledge of fundamental mathematical concepts, methods, and language to support further postgraduate study or a career in areas that require a mathematical background.
- Students develop the ability to communicate mathematical ideas clearly and accurately.

Requirements for the Major in Mathematics. Students complete the equivalent of 55 or 58 semester hours as described.

4	MATH-112 Calculus II
4	MATH-180 Statistical Methods
4	MATH-201 Linear Algebra
4	MATH-211 Multivariate Calculus
4	MATH-221 Discrete Structures
2	MATH-231 Foundations of Analysis
4	MATH-321 Abstract Algebra
4	MATH-353 Differential Equations
4	One 300-level or above mathematics course or PHYS-405 Mfathematical Physics
8	Two 400-level mathematics courses
1 or 4	MATH-500 Senior Colloquium
4	CSCI-181 Principles of Computer Science
8	Select one of the following two options: CSCI-281 Data Structures and one 300-level or above computer science course PHYS-204 Introductory Physics I (Calculus-based) and PHYS-206 Introductory Physics II

Teacher Certification. Coursework required by the state of Pennsylvania for admission to the teacher certification program includes successful completion of ENGL-100 Writing and Thinking or equivalent course, at least 3 semester hours in British or American literature, at least 6 semester hours of mathematics coursework (or other courses which satisfy the Central Curriculum Analytical Thought requirement), and at least one 40-hour externship.

Education course requirements for secondary education are EDUC-101 Introduction to Education and Society, EDUC-102 Historical and Philosophical Foundations of Education, EDUC-250 Educational Psychology, EDUC-260 Introduction to Special Education, EDUC-270 Instruction of Exceptional Students, EDUC-330 Technology in Education, EDUC-350 English Language Learners: Theory and Instruction, EDUC-380 Instructional Design, EDUC- 423 Methods of Curriculum, Instruction, and Assessment in Teaching Mathematics, EDUC-479 Principles of Learning and Teaching in Secondary Education, EDUC-483 Differentiated Instruction and Classroom Management in Secondary Education, and the EDUC-500 Student Teaching package (EDUC-501, EDUC-502, EDUC-503, and EDUC-600).

In addition, secondary education mathematics students complete all of the usual requirements for the mathematics major. They must satisfy the "one 300-level or above mathematics course" requirement by taking MATH-331 Geometry.

Interdisciplinary Options. Mathematics majors can easily complete a minor in another department. Areas such as accounting, business, computer science, biology, chemistry, physics or a modern language are natural choices. The department also sponsors a business-related minor in actuarial science.

Self-designed major. Highly motivated students whose interests cross traditional departmental lines may also consider a self-designed major. This option provides an integrated program of study from courses in several departments and is described in the majors and minors section.

Capstone. The capstone requirement may be satisfied by the four-semester-hour version of MATH-500 Senior Colloquium. Students need not fulfill the capstone requirement in their major, but they usually do.

COMPUTER SCIENCE

LEARNING GOALS:

- Students acquire knowledge of fundamental computer science and related mathematical concepts, together with programming skills, sufficient to support further postgraduate study or a career in computer science or related disciplines.
- Students develop the ability to design, implement, communicate and evaluate computing-based solutions as documented code to meet a given set of computing requirements in in a professional style.

Requirements for the Bachelor of Arts in Computer Science. To earn the Bachelor of Arts degree in computer science, students successfully complete, with grades of C- or better, the equivalent of the following 54 semester hours:

4	CSCI-181 Principles of Computer Science
4	CSCI-281 Data Structures
4	CSCI-282 Computer Organization
4	CSCI-381 Algorithms
4	MATH-111 Calculus I
4	MATH-180 Statistical Methods
4	MATH-201 Linear Algebra
4	MATH-221 Discrete Structures
22	300-level or above computer science courses

Requirements for the Bachelor of Science in Computer Science. To earn the Bachelor of Science degree in computer science, a student must complete, with grades of C- or better, the equivalent of the following 64 semester hours:

4	CSCI-181 Principles of Computer Science
4	CSCI-281 Data Structures
4	CSCI-282 Computer Organization
4	CSCI-381 Algorithms
4	MATH-111 Calculus I
4	MATH-112 Calculus II
4	MATH-180 Statistical Methods
4	MATH-201 Linear Algebra
4	MATH-221 Discrete Structures
4	Select one of the following two options: PHYS-101 Introduction to Digital and Analog Electronics PHYS-204 Introductory Physics I
24	300-level or above computer science courses

Capstone. The capstone requirement may be satisfied with one of the following courses: CSCI-472 Software Engineering: Practicum, CSCI-483 Compiler Theory or CSCI-500 Senior Colloquium.

Students need not fulfill the capstone requirement in their major, but they usually do. A capstone course taken as a junior does fulfill the requirement, but not as a sophomore.

Interdisciplinary Options. Students majoring in computer science can easily complete a minor in another department. Areas such as accounting, business, biology, chemistry, mathematics, physics or a modern language are natural choices. Highly motivated students whose interests cross traditional departmental lines may also wish to consider the self-designed major option, developing an integrated program of study from courses in several departments. For further information, see the majors and minors section.

Double Major/Minor in Computer Science and Mathematics. Because the computer science major already requires several mathematics courses, many computer science majors pick up a mathematics major or minor relatively easily. However, it is department policy that cross-listed elective courses (such as MATH-351/CSCI-351 Numerical Computing and MATH-352/CSCI/352 Numerical Analysis) count in only one major or minor at a time.

Departmental Honors. The departmental honors program encourages and recognizes outstanding academic performance. To graduate with departmental honors, a mathematics major or computer science major must do the following:

- Have a minimum GPA of 3.50 in the department and 3.00 overall,
- Request admission to the program at the end of the junior year,
- Consult with a faculty adviser to design an honors-quality project and begin research as a first-semester senior taking MATH-503 Independent Research or CSCI-503 Independent Research,
- Complete the project during the second semester in MATH-500 Senior Colloquium or CSCI-500 Senior Colloquium,
- Successfully pass an oral exam covering a selection of math courses.

Kappa Mu Epsilon. Students who meet national standards for membership are eligible to join this national undergraduate mathematics honorary society.

Minor in Actuarial Science. Students minoring in actuarial science will typically have strong interests in mathematics and business. Students taking this minor complete with grades of C- or better the following courses: MATH-211 Multivariate Calculus, MATH-441 Mathematical Statistics, MATH-351 Numerical Computing, MATH-352 Numerical Analysis, CSCI-401 Machine Learning, ACCT-200 Financial Accounting, FINC-340 Corporate Financial Management and either ECON-105 Elements of Economics or both ECON-201 Principles of Macroeconomics and ECON:202 Principles of Microeconomics.

Double-counting restriction for interdisciplinary minors: because this is an interdisciplinary minor, at least 16 semester hours of the minor must not be credited toward the student's major.

Minor in Computer Science. Students who minor in computer science successfully complete 24 semester hours, with grades of C- or better, in the following courses.

4	CSCI-181 Principles of Computer Science
4	CSCI-281 Data Structures
4	400-level computer science course
12	300-level or above computer science courses

Minor in Mathematics. The minor completes 24 semester hours of mathematics with grades of C- or better. Requirements include MATH-112 Calculus II, MATH-201 Linear Algebra, MATH-221 Discrete Structures, with at least four semester hours at the 300 level or above and 8 semester hours above the 108-level.

COMPUTER SCIENCE COURSES

CSCI-151 Introduction to Programming

An introductory course in computer science for nonmajors. The course teaches computer programming with emphasis on logical thinking, problem solving and algorithmic development. PROCESSING or a similar programming language is used. Topics include variables, arithmetic and logical operators, graphics, user interface, built-in library calls, I/O operations, conditional statements, loops, functions, and classes. 4 SH. CC: Analytical Thought.

CSCI-181 Principles of Computer Science

An introductory course in computer science for majors. Also open to nonmajors. Emphasizes computer problem- solving methods and algorithmic development. Topics include programming in Python or a comparable language, techniques of good programming style, data types, file and screen input and output, control structures, subroutines, recursion, arrays, and pointers. 4 SH. CC: Analytical Thought.

CSCI-200 Multi-agent Modeling in the Natural and Social Sciences

This course will explore some of what computer science has to offer to the natural and social sciences. Many phenomena consist of interacting individuals that can be modeled as following a set of behavioral rules. Using a suitable computer language such as NetLogo, Repast or others, we will learn to model these phenomena. Some programming experience is helpful but not required. Prerequisites: Fulfillment of the Analytic Thought requirement, sophomore standing and completion of either the Social Interactions requirement or the Scientific Explanations requirement. Some programming experience would be helpful but is not required. 4 SH. CC: Interdisciplinary.

CSCI-281 Data Structures

Second course in computer programming. Stresses the interplay between algorithms, data structures and their implementations. Topics include stacks, queues, linked lists, sorting, searching, binary trees and graphs. Prerequisite: CSCI-181 Principles of Computer Science. 4 SH.

CSCI-282 Computer Organization

Fundamentals of computer organization and machine architecture. Presents an overview of computer system organization and examines in detail the digital logic level, the register level and the operating system program interface. Uses the assembly language of an available machine for programming assignments. Prerequisite: CSCI- 281 Data Structures or instructor's permission. 4 SH.

CSCI-301 Data Mining

This course provides an introduction to the concepts in the automatic extraction of implicit, previously unknown and potentially useful information from large data that are generated in commerce, science and other areas. Topics include preprocessing of the data, application of the fundamental algorithms on the prepared data and interpretation of the patterns discovered by the algorithms. The fundamental algorithms for supervised learning, including classification and numerical prediction, and unsupervised earning, which includes association rules and clustering, are introduced. Prerequisites: CSCI-181 Principles of Computer Science and either MATH-180 Statistical Methods or both MATH-108 Introduction to Statistics, and INFS-233 Data Driven Decision Making, . 4 SH.

CSCI-351 Numerical Computing

An introduction to the computational techniques for solving mathematical problems, focusing on one-variable calculus. Topics include roots of nonlinear equations, finding maximum and minimum, interpolation, function approximation, numerical differentiation and integration. Same as CSCI-351. Prerequisite: MATH-111 Calculus I; MATH-112 Calculus II is suggested. 2 SH.

CSCI-352 Numerical Analysis

A study of the standard numerical techniques for solving mathematical problems, focusing on multivariable calculus and linear algebra. Topics include large sparse matrices, eigensystems, solving systems of equations, multivariable interpolation, maximum and minimum of multivariable functions, multivariable numerical integration, and numerical solutions of ordinary and partial differential equations. Same as CSCI-352. Prerequisites: MATH-112 Calculus II, MATH-201 Linear Algebra and MATH-351 Numerical Computing. 2 SH.

CSCI-370 Cryptology and Number Theory

Cryptology is the study of hiding the meaning of messages. Cryptology is an interesting venue for the study of its mathematical underpinnings (number theory, matrix algebra, probability and statistics) and as an opportunity to implement techniques by means of computer programs. We consider monoalphabetic and polyalphabetic encryptions, public key cryptography, security and anonymity. Same as MATH-370. Prerequisite: MATH-221 Discrete Structures. 4 SH.

CSCI-381 Algorithms

Introduces the design and implementation of algorithms using an object-oriented programming language such as C++ or Java. Covers correctness and efficiency of algorithms for sorting, searching, graph problems and mathematical algorithms. Prerequisites: MATH-221 Discrete Structures and CSCI-281 Data Structures. 4 SH.

CSCI-391 Data Communications and Networks I

An overview of data communications and networks, including channel capacity, Ethernet, Internet protocols, DHCP, DNS, TCP, FTP, SMTP, HTTP, Web servers and file sharing. Prerequisite: CSCI-181 Principles of Computer Science. 2 SH.

CSCI-392 Data Communications and Networks II

Further topics in networks, with an emphasis on security. Includes authentication, encryption, verification, certificates, digital signatures, attacks and defenses, privacy and anonymity. Also covers current developments in networks. Prerequisite: CSCI-391 Data Communications and Networks I. 2 SH.

CSCI-401 Machine Learning

This course provides an introduction to the systematic study of algorithms and systems that improve their knowledge or performance with experience. A statistical approach that emphasizes concepts and the implementation of the methods is presented to make sense of large and complex data. Topics include linear regression, classification, resampling methods, shrinkage approaches, tree-based methods, support vector machines and clustering. Prerequisites: MATH-180 Statistical Methods or MATH-108 Introduction to Statistics, and INFS-233 Data Driven Decision Making, MATH-201 Linear Algebra and CSCI-181 Principles of Computer Science. 4 SH.

CSCI-460 Application Programming

Programming in a common application environment, such as Android apps. Creation and management of windows, dialog boxes, mouse and keyboard input, message queues, graphics and multithreading. Prerequisite: CSCI-381 Algorithms. 4 SH

CSCI-471 Software Engineering: Methodology

The entire software development cycle is explored, from requirements gathering through analysis, design, implementation, testing and documentation procedures. This course discusses both the theory and the business- world reality of software development, with an emphasis on object-oriented methodologies. Prerequisite: CSCI-381 Algorithms or instructor's permission. 4 SH. CC: Writing Intensive.

CSCI-472 Software Engineering: Practicum

This course is designed to provide an experience similar to that of working in the software engineering industry. The methodologies discussed in CSCI-471 Software Engineering: Methodology are put into practice, as students work on project teams throughout one or more software development cycles. Current projects involve designing and developing software to guide a mobile robot. Prerequisites: Junior standing and CSCI-471 Software Engineering: Methodology. 4 SH. Capstone.

CSCI-481 Programming Languages

Studies the principles underlying various computer languages. Uses comparisons and evaluations of multiple programming languages such as C, Python, Java, FORTRAN, HTML, Postscript, LISP, and Prolog to introduce the broad principles of language design and implementation. Prerequisite: CSCI-281 Data Structures. 2 SH.

CSCI-382 Theory of Computation

An introduction to the classical and contemporary theory of computation. Topics include the theory of automata and formal languages, computability by Turing machines and recursive functions, computational complexity and possibly quantum computers. Same as MATH-382. Prerequisites: MATH-221 Discrete Structures and CSCI-281 Data Structures. 2 SH.

CSCI-483 Compiler Theory

Studies the phases of compiler design, such as syntax specification, lexical analysis, parsing, symbol tables, error detection, code optimization and code generation. Term project is to write a complete compiler for a small subset of C. Prerequisites: CSCI-282 Computer Organization and MATH-221 Discrete Structures. 4 SH. Capstone.

CSCI-484 Computer Graphics

Basic interactive graphics programming in 2-D and 3-D using a common graphics library such as OpenGL. Introduces fundamental hardware and software concepts to implement graphics. Covers topics of drawing points, curves, surfaces, lighting, shading, animation, geometrical transformation, representation of 3-D shapes, and removal of hidden edges and surfaces as time permits. Prerequisites: CSCI-281 Data Structures and MATH-201 Linear Algebra or instructor's permission. 2 SH.

CSCI-485 Artificial Intelligence

A brief summary of the tools, techniques and applications of artificial intelligence. Introduces problem solving and knowledge representation and selects topics from techniques for constructing models, robot design, language processing, computer vision, neural networks and expert systems. Same as INFS-485. Prerequisites: CSCI-281 Data Structures, MATH-111 Calculus I and either MATH-108 Introduction to Statistics or MATH-180 Statistical Methods. 2 SH.

CSCI-486 Introduction to Operating Systems

Introduction to the principles of operating systems through detailed discussion of a popular operating system such as Linux, with special attention to the areas of user interface, process management and file systems. Prerequisite: CSCI-281 Data Structures. 2 SH.

CSCI-487 Operating Systems

A study of general operating systems principles, processes, file systems, memory management, interprocess communication, I/O and concurrent processes. Includes a programming project in which the student writes a part of an operating system. Prerequisite: CSCI-486 Introduction to Operating Systems. 2 SH.

CSCI-488 Computer Architecture

A study of computer architecture, including logic circuits, CPU design, instruction sets, CISC, RISC, memory architecture, I/O, peripherals, pipelining, superscalar processors and multiprocessors. Includes hardware and software considerations. Prerequisite: CSCI-282 Computer Organization. 2 SH.

CSCI-500 Senior Colloquium

Experience in individual research and presentation of computer-related topics. Prerequisites: Senior standing and computer science department head's permission. 4 SH. Capstone. CC: Writing Intensive.

CSCI-501 Topics in Computer Science

Subjects vary depending on instructor and student interest. Example topics include software engineering, cryptography, parallel processing, digital video compression, object-oriented technologies, neural networks and others as approved. Prerequisite: Instructor's permission. 2 or 4 SH.

CSCI-502 Independent Study

Individual work for capable students under the supervision of a faculty member. Prerequisite: Instructor consent and approval of computer science department head. Regularly scheduled courses are approved for independent study only under extraordinary circumstances. 2 or 4 SH.

CSCI-503 Independent Research

A research project culminating in a substantive paper on a selected topic or field in computer science or information systems by arrangement with an instructor. Prerequisites: Junior or senior standing and department head's permission. 2 or 4 SH.

CSCI-599 Internship

Full-time employment in computer science or information systems at an industrial firm or a public service organization. Prerequisites: Senior standing, appropriate background courses in computer science and department internship coordinator's permission. S/U grade. 2, 4 or 8 SH.

MATHEMATICS COURSES

MATH-099 College Mathematics Preparation

Topics may include sets, radicals, polynomials, factoring, inequalities, linear and quadratic equations, functions, exponents, and simple descriptive statistics. Intended for students not ready for college credit math; placement in this course is determined by the Department of Mathematics. Grade is S/U. 0 SH.

MATH-101 Precalculus Mathematics

Topics include algebra, functions, graphing, exponents, logarithms, exponential functions, trigonometry and solving word problems. Prerequisite: Based on placement results, some students may require a mathematics review course. 4 SH.

MATH-105 Introductory Topics

This is a two-semester-hour course meant to help education majors satisfy the Pennsylvania state requirement for six credits of college mathematics. Each course will cover a topic of the instructor's choice at an introductory level. Topics so far have included symmetry, counting, and math and music. This course does not count toward a math major or minor, and particular topics may overlap enough with other math courses to bar a student from taking both. Education majors will be given priority. Prerequisites: Usually none. 2 SH.

MATH-108 Introduction to Statistics

A basic introduction to data analysis, descriptive statistics, probability, Bayes' Theorem, distributions of random variables and topics in statistical inference. (Students may earn credit for only one of the introductory statistics courses offered by the departments of management, psychology or mathematics.) 4 SH. CC: Analytical Thought.

MATH-111 Calculus I

Differentiation and integration of polynomials, exponential, logarithmic and trigonometric functions, rules of differentiation, the Mean Value Theorem, L'Hôpital's Rule, the Fundamental Theorem of Calculus, and applications. 4 SH. CC: Analytical Thought.

MATH-112 Calculus II

Techniques of integration. Also includes improper integrals, further applications of integration, and power series. Prerequisite: MATH-111 Calculus I or equivalent. 4 SH. CC: Analytical Thought.

MATH-180 Statistical Methods

This course provides a broad overview of introductory statistical methods and data analysis. Topics include descriptive statistics, probability, probability distributions, statistical inferences on population means and population variances, multiple comparisons, categorical data, data analysis using linear regression and multiple regression, design of experiments, and analysis of variance. 4 SH. CC: Analytical Thought.

MATH-201 Linear Algebra

Systems of linear equations, matrices and matrix algebra, vector spaces, linear transformations, inner product spaces, determinants, eigenvalues and eigenvectors, and selected applications. Prerequisite: MATH-111 Calculus I. 4 SH. CC: Analytical Thought.

MATH-211 Multivariate Calculus

Calculus of several variables, partial derivatives, critical points, multiple integrals, gradient, curl, divergence, Green's, Stokes', and Divergence Theorems. Prerequisites: MATH-112 Calculus II and MATH-201 Linear Algebra. 4 SH.

MATH-221 Discrete Structures

An introduction to the basic logical and set-theoretic framework of mathematics and computer science. Topics include logic, proof techniques, mathematical induction, divisibility and modular arithmetic, sets, relations, mappings, graphs, and counting principles. Prerequisite: MATH-111 Calculus I. 4 SH. CC: Analytical Thought.

MATH-231 Foundations of Analysis

A rigorous study of the theoretical basis of single-variable differential and integral calculus: limits, continuity, differentiation and integration. Prerequisite: MATH-112 Calculus II and MATH-221 Discrete Structures. 2 SH.

MATH-321 Abstract Algebra

An introduction to algebraic structures including groups, rings, and fields. Prerequisites: MATH-201 Linear Algebra and MATH-221 Discrete Structures. 4 SH. CC: Writing Intensive.

MATH-331 Geometry

A concentrated study of elementary geometry. Includes Euclidean and non-Euclidean geometries and selected topics such as symmetry, Penrose tilings, fractals, knots, mapmaking and the shape of the universe. Prerequisites: MATH-201 Linear Algebra and MATH-221 Discrete Structures. 4 SH.

MATH-351 Numerical Computing

An introduction to the computational techniques for solving mathematical problems, focusing on one-variable calculus. Topics include roots of nonlinear equations, finding maximum and minimum, interpolation, function approximation, numerical differentiation and integration. Same as CSCI-351. Prerequisite: MATH-111 Calculus I; MATH-112 Calculus II is suggested. 2 SH.

MATH-352 Numerical Analysis

MATH-352 Numerical Analysis. A study of the standard numerical techniques for solving mathematical problems, focusing on multivariable calculus and linear algebra. Topics include large sparse matrices, eigensystems, solving systems of equations, multivariate interpolation, maximum and minimum of multivariable functions, multivariable numerical integration, and numerical solutions of ordinary and partial differential equations. Same as CSCI-352. Prerequisites: MATH-112 Calculus II, MATH-201 Linear Algebra and MATH-351 Numerical Computing. 2 SH.

MATH-353 Differential Equations

Introduces theory, basic solution methods, qualitative analysis and applications of ordinary differential equations. Prerequisites: Sophomore standing, MATH-112 Calculus II and MATH-201 Linear Algebra or instructor's permission. 4 SH.

MATH-370 Cryptology and Number Theory

Cryptology is the study of hiding the meaning of messages. Cryptology is an interesting venue for the study of its mathematical underpinnings (number theory, matrix algebra, probability and statistics) and as an opportunity to implement techniques by means of computer programs. We consider monoalphabetic and polyalphabetic encryptions, public key cryptography, security, and anonymity. Same as CSCI-370. Prerequisite: MATH-221 Discrete Structures. 4 SH.

MATH-382 Theory of Computation

An introduction to the classical and contemporary theory of computation. Topics include the theory of automata and formal languages, computability by Turing machines and recursive functions, computational complexity, and possibly quantum computers. Same as CSCI-482. Prerequisites: MATH-221 Discrete Structures and CSCI-281 Data Structures. 2 SH.

MATH-411 Real Analysis

Limits and continuity in the general context of metric spaces. Topics include basic point-set topology, completeness, uniform continuity, sequences and series of functions. Additional topics as time permits. Prerequisites: MATH-112 Calculus II and MATH-231 Foundations of Analysis. 4 SH. CC: Writing Intensive.

MATH-415 Complex Analysis

Calculus using complex numbers. Includes analytic functions and the Cauchy-Riemann equations, contour integrals, Cauchy's Theorem, Cauchy's Integral Formula, power and Laurent series, poles, residues, and applications. Prerequisites: MATH-211 Multivariate Calculus, and MATH-231 Foundations of Analysis. 4 SH.

MATH-441 Mathematical Statistics

A more detailed study of statistics. Topics include probability, multivariate distributions, Bayes' Theorem, statistical inference, estimation, decision theory, hypothesis testing, linear models and experimental design. Prerequisites: MATH-211 Multivariate Calculus and either MATH-108 Introduction to Statistics or MATH-180 Statistical Methods. 4 SH.

MATH-500 Senior Colloquium

Experience in individual research and presentation of topics in mathematics. The one-semester-hour version culminates in a presentation to an audience of faculty and students. The 4 SH version satisfies the capstone requirement. Prerequisite: Senior major or department permission. 1 or 4 SH.

MATH-501 Topics in Mathematics

Subject depends on students' and instructor's interests. Possibilities include number theory, set theoretic foundations of mathematics, topology, graph theory, differential geometry and applied mathematics. Whether the course counts as a 400-level course for majors will be announced along with the course description. Prerequisite: Instructor's permission. 2 or 4 SH.

MATH-502 Independent Study

Individual work for capable students under faculty supervision. Scheduled courses are approved for independent study only under extraordinary circumstances. Whether the course counts as a 400-level course for majors will be decided on an individual basis. Prerequisite: Department approval and instructor's consent. 2 or 4 SH.

MATH-503 Independent Research

A research project leading to a substantive paper on a selected topic in mathematics. By arrangement with a department instructor. Prerequisites: Junior or senior standing and department permission. 2 or 4 SH.

MATH-599 Mathematics Internship

Full-time mathematics-related employment at an industrial firm or a public service organization. Prerequisites: Senior standing, appropriate mathematics background courses and department internship coordinator's permission. S/U grade. 2, 4 or 8 SH.