MATHEMATICS (MATH)

MATH 10088 Finite Mathematics (3 Credit Hours)
For achieving a qualifying score on the International Baccalaureate (IB) exam, students earn credit for this course as the exam credit equivalent of MATH 10120. Topics include the fundamental principles of counting systematically, probability, statistics, linear programming, optimization problems, game theory, and mathematical finance.

MATH 10089 Principles of Calculus (4 Credit Hours)
For achieving a qualifying score on the International Baccalaureate (IB) exam, students earn credit for this course as the exam credit equivalent of MATH 10150. Topics include functions and specific classes of functions such as rational, logarithmic and exponential, and trigonometric functions. Also included are limits, average rates of change, difference quotients, and derivatives.

MATH 10090 Elements of Calculus I (3 Credit Hours)
For achieving a qualifying score on the appropriate department exam, students earn credit for this course as the exam credit equivalent of MATH 10250. For students in arts and letters, architecture, or business. A study of basic calculus as part of a liberal education. It emphasizes conceptual learning and stresses the connections between mathematics and modern society. Topics include functions, limits, derivatives, and an introduction to integral, with interesting real-life applications throughout. Students are familiarized with the many different interpretations of the derivative as a rate of change, and the integral as a total rate of change. This enables them to learn and practice modeling in a variety of situations from economics the social and the life sciences.

MATH 10091 Calculus I (4 Credit Hours)
For achieving a qualifying score on the appropriate Advanced Placement (AP) exam, International Baccalaureate (IB) exam, or department exam, students earn credit for this course as the exam credit equivalent of MATH 10550. For students in science and engineering. Topics include sets, functions, limits, continuity, derivatives, integrals, and applications. Also covered are transcendental functions and their inverses, infinite sequences and series, parameterized curves in the plane, and polar coordinates.

MATH 10092 Calculus II (4 Credit Hours)
For achieving a qualifying score on the appropriate Advanced Placement (AP) exam, International Baccalaureate (IB) exam, or department exam, students earn credit for this course as the exam credit equivalent of MATH 10560. For students in science and engineering. Topics include sets, functions, limits, continuity, derivatives, integrals, and applications. Also covered are transcendental functions and their inverses, infinite sequences and series, parameterized curves in the plane, and polar coordinates.

MATH 10093 Calculus III (3.5 Credit Hours)
For achieving a qualifying score on the appropriate department exam, students earn credit for this course as the exam credit equivalent of MATH 20550. A comprehensive treatment of differential and integral calculus of several variables. Topics include space curves, surfaces, functions of several variables, partial derivatives, multiple integrals, line integrals, surface integrals, Stokes theorem, and applications.

MATH 10094 Introduction to Linear Algebra and Differential Equations (3.5 Credit Hours)
For achieving a qualifying score on the appropriate department exam, students earn credit for this course as the exam credit equivalent of MATH 20580. An introduction to linear algebra and to first-and second-order differential equations. Topics include elementary matrices, LU factorization, QR factorization, the matrix of a linear transformation, change of basis, eigenvalues and eigenvectors, solving first-order differential equations and second-order linear differential equations, and initial value problems. This course is part of a two-course sequence that continues with Math 30650 (325). Credit is not given for both Math 20580 (228) and Math 20610 (221).

MATH 10120 Finite Mathematics (3 Credit Hours)
The topics of finite mathematics broaden a student's mathematical horizon in an interesting direction not covered by calculus, which deals mostly with continuous models. The course begins with the fundamental principles of discrete mathematics, including sets, permutations, and counting systematically. Thereafter, these principles are seen in action in three indispensable areas of the modern world: probability, optimization, and game theory. Introducing students to probability theory, the course covers the main concepts of discrete probability, including random variables, dependence, statistics and Bayesian inference. The course introduces students to linear optimization from an intuitive, geometric, perspective using basic notions from linear algebra. Finally, the course applies basic concepts from linear algebra to game theory, including two-player mixed strategy games.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning
Students in the College of Engineering, College of Science or Mendoza College of Business colleges may **not** enroll.

MATH 10130 Beginning Logic (3-4 Credit Hours)
For students in arts and letters. Provide the students with some formal tools for analyzing arguments. By writing proofs in a formal system, students see the importance of stating the basic premises in an argument and giving intermediate steps that lead to the conclusion. They learn strategies for thinking up proofs. They see that proof checking is, in principle, something that a machine could do. Students learn truth tables and see an effective procedure that they could apply to any argument stated in propositional logic, to determine whether the conclusion follows logically from the premises. There is nothing like truth tables for predicate logic. Students get to experience doing what mathematicians do, trying to determine whether a particular conclusion follows from some premises by searching simultaneously for a proof or a counterexample. Writing papers gives students an opportunity to explore other topics in logic of their interest.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10150 Principles for Calculus (4 Credit Hours)
This course is meant as a gentle introduction to first semester Calculus. There will be an extensive review of functions and specific classes of functions such as rational, logarithmic and exponential, and trigonometric functions. The course will also cover limits, average rates of change, and difference quotients finishing with an introduction to derivatives.
Corequisites: MATH 12150

MATH 10250 Elements of Calculus (3 Credit Hours)
Calculus can be summarized as the study of change. Several fundamental ideas of calculus are over 2000 years old. This course is designed to build upon students' intuition to establish why the main ideas in calculus are natural and true, through consideration of the instantaneous position and velocity of a moving object. We will then be introducing 21st century techniques including Computer Algebra Systems to expand upon that intuition and generalize the main ideas of calculus to a variety of fields, including economics and life sciences. Students will be challenged to acquire a deep, personal understanding of calculus through reading the text and completing preview activities on their own, working on activities in small groups in class, and doing substantial exercises outside of class time. This course will strengthen students' written and oral communication skills by having them write about and explain aloud the key ideas of calculus.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning
Students in the College of Engineering or College of Science colleges may **not** enroll.

MATH 10260 Elements of Calculus II for Business (3 Credit Hours)
Credit is not given for both MATH 10280 and either of the following courses: MATH 10260 and MATH 10360. For students in business. An introduction to mathematical concepts, techniques, and ideas that are useful in understanding and solving problems that arise in economics and business. Most mathematical concepts are introduced through interesting business problems. Furthermore, by using available computer technology, real-life problems, that may lead to non-trivial computations and graphics are considered. Topics include integration, differential equations, Taylor polynomial approximations, unconstrained and constrained optimization for functions of several variables, probability and statistics, with interesting real-life applications throughout.
Prerequisites: MATH 10250 or MATH 10350 or MATH 10550 or MATH 10850
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10270 Mathematics in Architecture: Mathematical Excursions to the World's Great Buildings (3 Credit Hours)
As the Roman architect Vitruvius pointed out 2000 years ago, architecture is a broad enterprise bringing together virtually all the elements of the human experience: spirituality, intelligence and creativity, economics, politics and sociology, as well as aesthetics, structural engineering, and mathematics. The agenda of this course has a focus on the last three: aesthetics, structural aspects, and related mathematics. The architecture of the world's great historic buildings will be the environment in which the narrative of this course is developed. The aesthetic and structural properties of these structures will be described following a chronological line. Whenever the opportunity presents itself, this discussion will be informed by basic modern mathematics (such as geometry, trigonometry, and calculus). While the mathematical comments about the buildings considered are standard by today's criteria, they would (for the most part) have been beyond the reach of the architects who built them.
Prerequisites: MATH 10250 or MATH 10090 or MATH 10550 or MATH 10091 or MATH 10850 or MATH 10350
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10350 Calculus A (4 Credit Hours)
This is the first course of the two-semester Calculus sequence for life science and social science majors. Calculus A emphasizes the process of problem solving and application of calculus to the natural sciences, and requires students to think deeper about the concepts covered. Students will acquire basic skills needed for a quantitative approach to scientific problems. The course introduces the mathematics needed to study change in a quantity. Topics include functions, limits, continuity, rate of change of functions, integrals, graphing and their applications.
Prerequisites: MATH 10150
Corequisites: MATH 12350
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10360 Calculus B (4 Credit Hours)
This is the second course of the two-semester Calculus sequence for Life and Social science majors. Calculus B emphasizes the process of problem solving and application of calculus to the natural sciences, and requires students to think deeper about the concepts covered. Students will acquire basic skills needed for quantitative approach to scientific problems. The course introduces the mathematics needed to study change in a quantity. Topics include integration techniques, application of integrals to physics, geometry and ecology, solution of differential equations and their applications, and Taylor series.
Prerequisites: MATH 10350 or MATH 10550 or MATH 10091 or MATH 10850 or ACMS 10550
Corequisites: MATH 12360
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10450 Glynn Mathematics Seminar I (4 Credit Hours)
Mathematics is not about numbers and formulas, but about pattern and structures. According to Galileo, God wrote the world in the language of mathematics. To communicate in this language efficiently, one has to be convincing. This is where the concept of PROOF, perhaps the most feared and misunderstood in undergraduate courses, comes in. In this course, we will see how the main rules and tools of rigorous mathematical reasoning appear naturally in a general approach to framing, analyzing, and solving problems inspired by the world around us. The ultimate goal is to learn to think critically, to question your assumptions, and master the power of logical deduction. The specific topics will vary from year to year and may include the theory of numbers, exploration of symmetry, classification of geometric shapes, counting and combinatorics.
Corequisites: MATH 12450
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10460 Glynn Mathematics Seminar II (4 Credit Hours)
Mathematics is not about numbers and formulas, but about pattern and structures. According to Galileo, God wrote the world in the language of mathematics. In this course we will encounter the world of real mathematics with a particular focus on mathematical reasoning. This is not just being able to understand or prove theorems, but a general approach to framing, analyzing, and solving problems of many types. The ultimate goal is to think critically about the world, to question your assumptions, and master the power of logical deduction. The topics will vary each semester, but each year we will include set theory and the beginning of logic: logical connectives, truth tables, Venn diagrams, argument forms, soundness, validity, inductive and deductive arguments, translating natural language arguments, conditional statements, logical fallacies, syllogisms. To start out the first semester you will develop the ability to construct, write, and explain mathematical proofs of various sorts: direct proofs, proofs by contradiction, mathematical induction, case analysis, and counterexamples. As the first semester continues and on into the second, we will focus on particular mathematical topics. These will vary somewhat from year to year, but the following are good examples: number theory, symmetry and group theory, topology of surfaces, notions of infinity, counting and combinatorics.
Prerequisites: MATH 10450
Corequisites: MATH 12460
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10550 Calculus I (4 Credit Hours)
For students in science and engineering. Topics include sets, functions, limits, continuity, derivatives, integrals, and applications.
Prerequisites: MATH 10150
Corequisites: MATH 12550
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10555 Calculus Workshop (1 Credit Hour)
This course is intended for preparation for Calculus 1 or Calculus A. We will review pre-calculus and algebra material while also introducing concepts of limits and derivatives.

MATH 10560 Calculus II (4 Credit Hours)
For students in science and engineering. Topics include integration and applications, transcendental functions and their inverses, infinite sequences and series, parameterized curves in the plane, and polar coordinates.
Prerequisites: MATH 10550 or MATH 10091 or MATH 10850 or MATH 10350
Corequisites: MATH 12560
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10850 Honors Mathematics I (4 Credit Hours)
This is not your high school Calculus course. Aimed at highly engaged math students, Honors Calculus emphasizes the 'why' of mathematics as well as the 'how'. Specifically, it begins with a thorough introduction to mathematical reasoning and proofs and then proceeds to carefully develop the central topics (limits, differentiation, integration) of one variable Calculus. Whether you have had Calculus before or not, this course will challenge you in new ways. It will strongly enhance your critical thinking skills and provide you with a much more solid grounding for any future mathematics courses. Honors calculus courses are required for the honors math major, but they have much to offer for mathematically inclined students of all majors. Math majors with AP credit for Calculus 1 and 2 may count Honors Calculus 1 and 2 in place of the upper level math courses Introduction to Mathematical Reasoning (20630) and Real Analysis (30850).
Corequisites: MATH 12850
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 10860 Honors Mathematics II (4 Credit Hours)
This is not your high school Calculus course. Aimed at highly engaged math students, Honors Calculus emphasizes the 'why' of mathematics as well as the 'how'. Specifically, it begins with a thorough introduction to mathematical reasoning and proofs and then proceeds to carefully develop the central topics (limits, differentiation, integration) of one variable Calculus. Whether you have had Calculus before or not, this course will challenge you in new ways. It will strongly enhance your critical thinking skills and provide you with a much more solid grounding for any future mathematics courses. Honors calculus courses are required for the honors math major, but they have much to offer for mathematically inclined students of all majors. Math majors with AP credit for Calculus 1 and 2 may count Honors Calculus 1 and 2 in place of the upper level math courses Introduction to Mathematical Reasoning (20630) and Real Analysis (30850).
Prerequisites: MATH 10850
Corequisites: MATH 12860
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 11550 Calc Lab (1 Credit Hour)
The goal of this course is to explore topics related to those you are encountering in math 10550/10560 in such a way that helps expand your understanding of Calculus and excite you about how it fits in with your overall program of study. Click on specific sections to get more information about what applications specifically will be covered in that section.
Prerequisites: MATH 10550 (may be taken concurrently) or MATH 10560 (may be taken concurrently) or MATH 20550 (may be taken concurrently)
Course may be repeated.

MATH 11560 Calculus Lab (1 Credit Hour)
The goal of this course is to explore topics related to those you are encountering in math 10550/10560 in such a way that helps expand your understanding of Calculus and excite you about how it fits in with your overall program of study. Click on specific sections to get more information about what applications specifically will be covered in that section.
Course may be repeated.

MATH 12150 Principles for Calculus Tutorial (0 Credit Hours)
Tutorial for this course that is meant as a gentle introduction to first semester Calculus. There will be an extensive review of functions and specific classes of functions such as rational, logarithmic and exponential, and trigonometric functions. The course will also cover limits, average rates of change, and difference quotients finishing with an introduction to derivatives.
Corequisites: MATH 10150

MATH 12350 Calculus A Tutorial (0 Credit Hours)
Tutorial for the first course of the two-semester Calculus sequence for life science and social science majors. Calculus A emphasizes the process of problem solving and application of calculus to the natural sciences, and requires students to think deeper about the concepts covered. Students will acquire basic skills needed for a quantitative approach to scientific problems. The course introduces the mathematics needed to study change in a quantity. Topics include functions, limits, continuity, rate of change of functions, integrals, graphing and their applications.
Corequisites: MATH 10350

MATH 12360 Calculus B Tutorial (0 Credit Hours)
Tutorial for the second course of the two-semester Calculus sequence for Life and Social science majors. Calculus B emphasizes the process of problem solving and application of calculus to the natural sciences, and requires students to think deeper about the concepts covered. Students will acquire basic skills needed for quantitative approach to scientific problems. The course introduces the mathematics needed to study change in a quantity. Topics include integration techniques, application of integrals to physics, geometry and ecology, solution of differential equations and their applications, and Taylor series.
Corequisites: MATH 10360

MATH 12450 Glynn Mathematics Seminar I Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10450

MATH 12460 Glynn Math Seminar II Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10460

MATH 12550 Calculus I Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10550

MATH 12560 Calculus II Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10560

MATH 12850 Honors Mathematics I Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10850

MATH 12860 Honors Mathematics II Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 10860

MATH 13187 Mathematics University Seminar (3 Credit Hours)
A course for first-year students devoted to an introductory topic in mathematics, with an emphasis on the fundamentals of academic writing.
Satisfies the following University Core Requirements: USEM - University Seminar, WKQR- Core Quantitat Reasoning
Students in the Holy Cross College or St. Mary's College colleges may **not** enroll.

MATH 13550 Calculus Problem Solving (1 Credit Hour)
The goal of this course is to explore topics related to those you are encountering in math 10550/10560 in such a way that helps expand your understanding of Calculus and excite you about how it fits in with your overall program of study. Click on specific sections to get more information about what applications specifically will be covered in that section.
Students with the Galvin STEM Scholars (GALV) attribute may **not** enroll.

MATH 13560 Calculus II - Problem Solving (1 Credit Hour)
The goal of this course is to explore topics related to those you are encountering in math 10550/10560 in such a way that helps expand your understanding of Calculus and excite you about how it fits in with your overall program of study. Click on specific sections to get more information about what applications specifically will be covered in that section.
Corequisites: MATH 10560
Students with the Galvin STEM Scholars (GALV) attribute may **not** enroll.

MATH 14360 Calculus B for the Life and Social Sciences (4 Credit Hours)
This is a second-semester calculus course designed for biology and social science majors. It is required for all premedical students. Mathematics plays a prominent role in the understanding of complex systems in modern biology and social science. This course aims to develop basic mathematical literacy in students for this modern era. Students will acquire skills needed for a quantitative approach to scientific problems and the mathematics needed to study change in a quantity. Topics include integration techniques, solution of differential equations, geometric series, Taylor series and their applications to physics, geometry and ecology. Pre-requisites: First semester calculus or freshmen calculus. <p> Note: this course is delivered fully online. The course design combines required live weekly meetings online with self-scheduled lectures, problems, assignments, and interactive learning materials. To participate, students will need to have a computer with webcam, reliable internet connection, and a quiet place to participate in live sessions.
Prerequisites: MATH 10350 or MATH 10450 or MATH 10550 or MATH 10091 or MATH 10850
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 14550 Calculus I (3-4 Credit Hours)
For students in science and engineering. Topics include sets, functions, limits, continuity, derivatives, integrals, and applications. Also covered are transcendental functions and their inverses, infinite sequences and series, parameterized curves in the plane, and polar coordinates.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20180 Introduction to Mathematical Writing and History (2-3 Credit Hours)
A course for first-year students devoted to an introductory topic in mathematics, with an emphasis on proof techniques and the fundamentals of academic writing.
Prerequisites: MATH 10850 or MATH 20550
Satisfies the following University Core Requirements: WRIT - Writing Intensive

MATH 20192 Philosophy of Mathematics (3 Credit Hours)
A survey of central issues in the philosophy of mathematics.

MATH 20480 Intro to Dyn Sys for Scientist (3 Credit Hours)
This is a one-semester course introducing students to linear algebra and ordinary differential equations by way of their scientific usage. The course serves as a gateway to more advance mathematical methods that are commonly used in contemporary scientific studies and their literature. Students will learn how to take a mathematical approach to various scientific problems, solve the resulting equations, and interpret the mathematical solution in the original context. There will be course projects and some usage of computing software. Topics include matrix algebra, eigenvalues and eigenvectors, vector-valued functions, linear and non-linear systems of differential equations, and phase portraits. The scientific topics include age-structured population growth, the Richardson's theory of war, and infectious disease modeling.
Prerequisites: MATH 10260 or MATH 10360 or MATH 10560 or MATH 10092
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20550 Calculus III (3.5 Credit Hours)
A comprehensive treatment of differential and integral calculus of several variables. Topics include space curves, surfaces, functions of several variables, partial derivatives, multiple integrals, line integrals, surface integrals, Stokes theorem, and applications.
Prerequisites: MATH 10560 or MATH 10092 or MATH 10860 or MATH 10360 or MATH 19561 or MATH 19562 or MATH 19563 or ACMS 10560
Corequisites: MATH 22550
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20570 Mathematical Methods in Physics I (3.5 Credit Hours)
A study of methods of mathematical physics. Topics include matrices, linear algebra (including matrices and determinants), vector and tensor analysis, vector calculus, curvilinear coordinates, series, ordinary differential equations, partial differential equations, orthogonal functions and vector spaces, special functions (including Bessel, Legendre, and Hermite), calculus of variations, Fourier series, and group theory. Weekly tutorial sessions. Cross-listed with PHYS 20451 (271).
Prerequisites: MATH 10560 or MATH 10092 or MATH 10860
Corequisites: MATH 22570
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20580 Introduction to Linear Algebra and Differential Equations (3.5 Credit Hours)
An introduction to linear algebra and to first-and second-order differential equations. Topics include elementary matrices, LU factorization, QR factorization, the matrix of a linear transformation, change of basis, eigenvalues and eigenvectors, solving first-order differential equations and second-order linear differential equations, and initial value problems. This course is part of a two-course sequence that continues with Math 30650. Credit is not given for both Math 20580 and Math 20610.
Prerequisites: MATH 20550 or ACMS 20550 or MATH 10093 or MATH 24550
Corequisites: MATH 22580
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20610 Linear Algebra (3 Credit Hours)
Open to all students. An introduction to vector spaces, matrices, linear transformations, inner products, determinants and eigenvalues. Emphasis is given to careful mathematical definitions and understanding the basic theorems of the subject. Credit is not given for both MATH 20610 (221) and MATH 20580 (228).
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20630 Introduction to Mathematical Reasoning (3 Credit Hours)
This course serves as a transition to upper-level math courses. The general subject is numbers of all sorts-integers, rationals, reals, etc. The main point will be to treat everything the way a mathematician would. That is, we will give precise definitions of the objects we consider and careful statements of the assertions we make about them. And, most importantly, we will justify our assertions by giving mathematical proofs. Topics covered include basic language of sets, common methods of proof, integers, factorization, modular arithmetic, rational numbers, completeness, real numbers, cardinality, limits, and continuity.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20670 Mathematical Methods in Physics II (3.5 Credit Hours)
A study of methods of mathematical physics. Topics include linear algebra (including matrices and determinants), vector and tensor analysis, vector calculus, curvilinear coordinates, series, ordinary differential equations, partial differential equations, orthogonal functions and vector spaces, special functions (including Bessel, Legendre, and Hermite), calculus of variations, Fourier series, and group theory. Weekly tutorial sessions.
Corequisites: MATH 22670
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20750 Ordinary Differential Equations (3 Credit Hours)
An introduction to differential equations. Topics include first-order equations, n-th order linear equations, power series methods, systems of first order linear equations, non-linear systems and stability. Credit is not given for both MATH 20750 (230) and MATH 30650 (325).
Prerequisites: MATH 20610
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20810 Honors Algebra I (3 Credit Hours)
A comprehensive treatment of vector spaces, linear transformations, inner products, determinants, eigenvalues, tensor and exterior algebras, spectral decompositions of finite-dimensional symmetric operators, and canonical forms of matrices. The course stresses careful mathematical definitions and emphasizes the proofs of the standard theorems of the subject.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20820 Honors Algebra II (3 Credit Hours)
A comprehensive treatment of vector spaces, linear transformations, inner products, determinants, eigenvalues, tensor and exterior algebras, spectral decompositions of finite-dimensional symmetric operators, and canonical forms of matrices. The course stresses careful mathematical definitions and emphasizes the proofs of the standard theorems of the subject.
Prerequisites: MATH 20810
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20850 Honors Mathematics III (4 Credit Hours)
This is a two semester sequence integrating linear algebra and multivariable calculus, intended for students with a strong interest in and aptitude for math. Topics covered include algebra and geometry of vectors and linear transformations; continuity, differentiation and integration for functions of several variables; and various applications of all these things. Material will be covered in substantially greater depth than in similar courses (e.g. Calculus 3), with strong emphasis on both computation and careful mathematical argument (i.e. proofs). Honors Calculus 1 and 2 (Math 10850/60 is the normal prerequisite for Honors Calculus 3 and 4, but highly motivated students with exceptionally strong mathematical backgrounds may request permission (from the director of honors math) to skip the earlier sequence and enroll directly in Honors Calculus 3.
Prerequisites: MATH 10860
Corequisites: MATH 22850
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20860 Honors Mathematics IV (4 Credit Hours)
This is a two semester sequence integrating linear algebra and multivariable calculus, intended for students with a strong interest in and aptitude for math. Topics covered include algebra and geometry of vectors and linear transformations; continuity, differentiation and integration for functions of several variables; and various applications of all these things. Material will be covered in substantially greater depth than in similar courses (e.g. Calculus 3), with strong emphasis on both computation and careful mathematical argument (i.e. proofs). Honors Calculus 1 and 2 (Math 10850/60 is the normal prerequisite for Honors Calculus 3 and 4, but highly motivated students with exceptionally strong mathematical backgrounds may request permission (from the director of honors math) to skip the earlier sequence and enroll directly in Honors Calculus 3.
Prerequisites: MATH 20850
Corequisites: MATH 22860
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 20985 The Math of COVID-19 (1.5 Credit Hours)
In this 3-week course, we will explore mathematical tools that can help us understand and address the COVID-19 pandemic. The course will have three parts. First, we will see how differential equations can be used to model the spread of COVID-19. Next, we will explore the mathematics of group testing, which is a method for testing a population for COVID with fewer than one test per person. The final week of the course will be project-based. We will break into groups and using the tools we have learned, each will make testing recommendations to a fictional client (for example a company, school, sports league). There will be a final presentation.

MATH 22550 Calculus III Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 20550

MATH 22570 Mathematical Methods in Physics I Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 20570

MATH 22580 Linear Algebra and Differential Equations Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 20580

MATH 22670 Mathematical Methods in Physics II Tutorial (0 Credit Hours)
Required tutorial for MATH 20670.
Corequisites: MATH 20670

MATH 22850 Honors Mathematics III Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 20850

MATH 22860 Honors Mathematics IV Tutorial (0 Credit Hours)
Perfecting problem-solving skills in smaller group settings.
Corequisites: MATH 20860

MATH 24213 Outwit, Outplay, Outlast: The Dynamics of Survivor (3 Credit Hours)
The American Reality TV show Survivor has been a part of American culture for over 2 decades. To quote the host Jeff Probst, "Survivor is a microcosm for our real world." In this course, we will look at this iconic TV show and generalize its infamous moments to experiences people have in the real world. Because Survivor is a game of social deception, studying its dynamics is especially relevant for those who want to understand negotiation, business, leadership, academia, or virtually any other work — and many personal — situations. We look to discover and analyze the art of decision making through the principles of Social Cognitive Neuroscience and Mathematical Game Theory. By the end of this course, students will be able to utilize the fundamentals of mathematical game theory to deconstruct complex real world situations with payoff matrices and formulate strategies for idealized outcomes. Additionally, students will identify the key frameworks of social cognitive neuroscience to be able to articulate challenges to the concept of humans as optimal decision-making agents and relate affective, social, and cognitive influences on decision-making to real-life situations. Finally students will end the course with role-playing in a Survivor like game and use the skills in this course to document and analyze their experiences.

MATH 24550 Calculus III (2.5-4 Credit Hours)
This is an online course with required, regular class sessions each week. Class meetings are online via Zoom webinar software (provided by the University). A comprehensive treatment of differential and integral calculus of several variables. Topics include space curves, surfaces, functions of several variables, partial derivatives, multiple integrals, line integrals, surface integrals, Stokes theorem, and applications. <p> Note: this course is delivered fully online. The course design combines required live weekly meetings online with self-scheduled lectures, problems, assignments, and interactive learning materials. To participate, students will need to have a computer with webcam, reliable internet connection, and a quiet place to participate in live sessions.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 24580 Introduction to Linear Algebra and Differential Equations (3 Credit Hours)
An introduction to linear algebra and to first-and second-order differential equations. Topics include elementary matrices, LU factorization, QR factorization, the matrix of a linear transformation, change of basis, eigenvalues and eigenvectors, solving first-order differential equations and second-order linear differential equations, and initial value problems. This course is part of a two-course sequence that continues with Math 30650 (325). Credit is not given for both Math 20580 (228) and Math 20610 (221). PA description (202320): This unit provides students with a foundation in linear algebra, sequences Taylor series, Fourier series, Laplace transforms and ordinary differential equations. It covers essential concepts and techniques required for science, engineering and higher mathematics.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 24610 Linear Algebra (3-4 Credit Hours)
This unit is required for students intending to major in Applied or Pure Mathematics or Mathematical Statistics, students in Engineering and students in some of the physical sciences. It is also suitable for other students wishing to have a strong mathematics component in their degrees. Topics include methods of proof, logic and mathematical induction; infinite sequences, bounded and monotone sequences; limits and continuity of functions; differentiability; integration; the fundamental theorem of calculus; Taylor polynomials; infinite series, absolute and conditional convergence, power series, ratio and comparison tests; vector geometry; systems of linear equations and Gaussian elimination; matrix algebra; subspaces, linear independence, bases and dimension, the rank-nullity theorem for matrices; eigenvalues and eigenvectors.

MATH 24630 Combinatorics, Number Theory, and Math Reasoning (3 Credit Hours)
In this module we introduce and develop some of the basic ideas in the areas of Combinatorics and Number Theory. A sample of topics covered are: mathematical induction; permutations and combinations; counting arguments; modular arithmetic; Euclidean algorithm; Fermat's and Euler's theorems; fundamental theorem of arithmetic; systems of linear congruences and the Chinese remainder theorem.

MATH 25150 Principles of Calculus: Problems & Pedagogy (0 Credit Hours)
This course is intended for upper-class undergraduate students currently serving as Huddle leaders in a Principles of Calculus lecture course (instructor approval is required for enrollment). The purpose of this course is to engage in collaborative problem-solving and review current topics from the corresponding Principles of Calculus lecture, in preparation for supporting undergraduate learners in peer-facilitated study groups.
Course may be repeated.

MATH 25550 Calculus A/I: Problems and Pedagogy (0 Credit Hours)
This course is intended for upper-class undergraduate students currently serving as Huddle leaders in a Calculus A/I lecture course (instructor approval is required for enrollment). The purpose of this course is to engage in collaborative problem-solving and review current topics from the corresponding Calculus A/I lecture, in preparation for supporting undergraduate learners in peer-facilitated study groups.

MATH 30210 Introduction to Operations Research (3 Credit Hours)
Operations research is the science (and art) of decision making. The success of a decision is frequently quantified through an achievement of certain goals (objectives) under restrictions imposed on various resources. Thus, mathematical models of operations research are frequently described as optimization problems, i.e. problems of minimization (maximization) of an objective function subject to various constraints. In this course we will consider optimization problems most frequently arising in various applications. Namely, linear programming problems, i.e. problems of minimization of a linear function subject to linear constraints. We will discuss in detail the simplex algorithm for solving linear programming problems and duality theory (optimality conditions). The Transportation Problem is a particular case of a linear programming which has various applications and specific algorithms. The Assignment Problem is an important example of so-called discrete optimization problems which can be solved using ideas of linear programming. We discuss both problems in detail. Game Theory is typically used in decision making with conflicting interests. We will discuss two person zero-sum games and show how the simplex algorithm can be used to solve them. If time permits, we will consider some applications of optimization theory to financial mathematics.
Prerequisites: MATH 20580 or MATH 10094 or MATH 20610 or MATH 20480 or MATH 20670 or PHYS 20452 or ACMS 20620
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30310 Coding Theory (3 Credit Hours)
This course provides an elementary treatment of the theory of error-correcting codes. Topics include an introduction to finite fields and vectors over finite fields, linear codes, encoding and decoding with a linear code, Hamming codes, perfect codes, codes based on latin squares, cyclic codes, MDS codes, weight enumerators.
Prerequisites: MATH 20580 or MATH 10094 or MATH 20610 or MATH 20810 or ACMS 20620
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30530 Introduction to Probability (3 Credit Hours)
An introduction to the theory of probability, with applications to the physical sciences and engineering. Topics include discrete and continuous random variables, conditional probability and independent events, generating functions, special discrete and continuous random variables, laws of large numbers and the central limit theorem. The course emphasizes computations with the standard distributions of probability theory and classical applications of them.
Prerequisites: MATH 20850 or MATH 20550 or MATH 10093
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30540 Mathematical Statistics (3 Credit Hours)
An introduction to mathematical statistics. Topics include distributions involved in random sampling, estimators and their properties, confidence intervals, hypothesis testing including the goodness-of-fit test and contingency tables, the general linear model and analysis of variance.
Prerequisites: MATH 30530
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30610 Introduction to Financial Mathematics (3 Credit Hours)
The course serves as a preparation for first actuarial exam in financial math- ematics, known as Exam FM or Exam 2. The first part of the course deals with pricing of fixed income securities, such as bonds and annuities. The second part of the course can serve as an introduction to deriva- tive securities such as options and futures. Although the amount of material for both parts is almost the same, exam FM devotes usually about 2/3 of its questions to Part1. Therefore, about 2/3 of the course is devoted to Part 1. Topics covered: Interest rates, Annuities, Loans and Bonds, Forwards, Options, Hedging, and Swaps
Prerequisites: (MATH 30530 or ACMS 30530) and (MATH 20610 or MATH 20550 or MATH 10093)
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30650 Differential Equations (3 Credit Hours)
A second course in differential equations. Topics include higher order linear equations, numerical methods, Laplace transforms, linear systems, non-linear systems and stability, and an introduction to partial differential equations and Fourier series.
Prerequisites: MATH 20580 or MATH 10094
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30710 Algebra (3 Credit Hours)
An introduction to groups, rings and fields. Topics include permutations, divisibility, modular arithmetic, cryptography, cyclic and dihedral groups, Lagrange's theorem, homomorphisms, ideals, integral and Euclidean domains, extension fields.
Prerequisites: MATH 20630 and MATH 20610
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30750 Real Analysis (3 Credit Hours)
A rigorous treatment of differential and integral calculus. Topics include a review of sequences and continuity, differentiability, Taylor's theorem, integration, the fundamental theorem of Calculus, pointwise and uniform convergence, and power series. Additional topics are likely and will depend on the instructor. Emphasis throughout will be on careful mathematical definitions and thorough understanding of basic results.
Prerequisites: MATH 20630
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30810 Honors Algebra III (3 Credit Hours)
A comprehensive treatment of groups, polynomials, rings, homomorphisms, isomorphism theorems, field theory, and Galois theory. The course stresses careful mathematical definitions and emphasizes the proofs of the standard theorems of the subject.
Prerequisites: MATH 20820
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30820 Honors Algebra IV (3 Credit Hours)
Required of honors mathematics majors. A comprehensive treatment of groups, polynomials, rings, homomorphisms, isomorphism theorems, field theory, and Galois theory. The course stresses careful mathematical definitions and emphasizes the proofs of the standard theorems of the subject.
Prerequisites: MATH 30810
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30850 Honors Analysis I (3 Credit Hours)
Required of honors mathematics majors. An advanced course in mathematical analysis in one and several variables. Topics include an axiomatic formulation of the real and complex number systems, compactness, connectedness, metric spaces, limits, continuity, infinite sequences and series, differentiation, the Riemann-Stieltjes integral, the Stone-Weierstrass theorem, the implicit function theorem, differential forms, partitions of unity, simplexes and chains, and Stokes' theorem.
Prerequisites: MATH 20860
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 30860 Honors Analysis II (3 Credit Hours)
Required of honors mathematics majors. An advanced course in mathematical analysis in one and several variables. Topics include an axiomatic formulation of the real and complex number systems, compactness, connectedness, metric spaces, limits, continuity, infinite sequences and series, differentiation, the Riemann-Stieltjes integral, the Stone-Weierstrass theorem, the implicit function theorem, differential forms, partitions of unity, simplexes and chains, and Stokes' theorem.
Prerequisites: MATH 30850

MATH 34530 Introduction to Probability (1-4 Credit Hours)
An introduction to the theory of probability, with applications to the physical sciences and engineering. Topics include discrete and continuous random variables, conditional probability and independent events, generating functions, special discrete and continuous random variables, laws of large numbers and the central limit theorem. The course emphasizes computations with the standard distributions of probability theory and classical applications of them.

MATH 34650 Differential Equations (3-5 Credit Hours)
Students are able to (1) understand and employ the fundamental theorems of multivariable calculus; (2) understand and apply Green's theorem, Stokes' theorem and the Divergence theorem; (3) understand and employ complex analysis, particularly the method of residues; (4) understand and employ techniques of Fourier series; (5) employ methods of solution of both ordinary and partial differential equations; and (6) understand any apply Sturm-Liouville theory. The object of this module is to provide a broad introduction to analytical methods for solving ordinary and partial differential equations and to develop students' understanding and technical skills in this area. This module is a prerequisite for several other Honours options. The syllabus includes: existence and uniqueness of solutions to initial-value problems; non-linear ODE's; Green's functions for ODE's; Sturm-Liouville problems; first order PDE's; method of characteristics; classification of second order linear PDE's; method of separation of variables; characteristics and reduction to canonical form.
Prerequisites: (MATH 20580 or MATH 10094) or MATH 24580

MATH 34710 Algebra (3-4 Credit Hours)
"MATH 30100 Field Theory at UCD; This course gives an introduction to field theory, with an emphasis on the study of finite fields, which underlies many modern applications. Axioms, properties and constructions of arbitrary fields will be described. Fields will be viewed both as vector spaces and as quotients of polynomial rings. While the study of fundamental infinite fields will be given a rigourous treatment, students will also study properties of finite fields in a concrete way. Standard techniques used in the manipluation of the algebra of finite fields will be introduced. Applications of finite fields arise naturally in digital technology, such as coding theory, cryptography or sequences. Some of these applications will be described here. During the course of this module, students will:1. become familiar with the properties of a field;2. have a knowledge of constructions and properties of important classes of fields; 3. be furnished with an understanding of field theory so that further studies in algebra reliant on field theory can be undertaken, such as Galois theory, number theory and commutative algebra;4. have a concrete understanding of finite fields, including manipulation of additive and multiplicative representations of elements;5. be familiar with the Frobenius automorphism and trace map and their use as tools in the study of finite fields;6. be familiar with important applications of finite fields related to the mathematics of communications theory." When taught in Perth: The theme of this unit is the theory of groups, and their use in measuring symmetry with special emphasis on geometric examples. Apart from the mathematical interest of groups, they are of great and increasing importance in chemistry, geology and physics, and those aspects that have significance in such disciplines are strongly emphasised. The fundamental notion is that of a group action. Group actions are used to elucidate the structure of a group, culminating in the Sylow theorems, which connect finite groups and number theory. The applications of group actions extend to symmetries of the plane, three-space and higher dimensional spaces, rotation and spin, crystallographic groups and symmetries of regular figures in two and three dimensions. Other algebraic structures such as rings and fields may also be explored. When taught at Trinity College Dublin: Sets, their unions, intersections, differences, direct (or cartesian) products. Subsets. Maps between sets, injective, surjective and bijective maps. Images and preimages of subsets. Composition of maps. Identity map, the inverse of a map, right and left inverses. Binary operations on sets. Associativity, multiplicativity. Identity and inverse elements with respect to a binary operation. Groups, semigroups, monoids. Cayley table of a group. Direct products of groups. Subgroups. Intersections of subroups. Generators of a subgroup. Permutation group of a set (the group of all bijective self-maps). Symmetric group Sn. Parity (sign) of a permutation, even and odd permutations. Alternating subgroup An of Sn. Group of Isometries. Matrix groups GLn, SLn, On, SOn, Un, SUn. Integer division with remainder. Additive subgroups of Z. Greatest common divisor. Euclidean algorithm. Unique prime factorization. Binary relations, equivalence relations, partitions. Congruence relation and classes of integers modulo n. The set of congruence classes Zn modulo n as additive group and multiplicative monoid. Multiplicative group Zn*. Cosets of a subgroup in a group. Lagrange's Theorem. Group homomorphisms and isomorphisms. Kernel of homomorphism. Normal subgroup. Quotient group modulo normal subgroup. First isomorphism theorem. Chinese remainder theorem. Group actions on a set. Stabilizers and orbits of a group action. Sylow's Theorem. Classification of finite abelian groups.

MATH 34750 Real Analysis (3-4.5 Credit Hours)
The follwoing more robust course description was provided for the version of the course taught at UCD in Dublin. "Analysis" is a module designed to introduce to students some of the theory developed on sequences and series in the 19th century. The student will be introduced to the concept of a sequence of real numbers and will learn about various other concepts such as that of convergent sequence, bounded sequence and monotonic sequence to name a few. The Axiom of Completeness will be introduced and the student will see its role in proving results such as the Monotone Convergence Theorem and Bolzano-Weierstrass Theorem. The concepts of countable and uncountable sets will also be discussed and the student will learn that the set of real numbers is uncountable. The latter part of the module deals with tests of convergence for series and looks at the concepts of conditional and absolute convergence. The module concludes with a discussion of power series and Taylor series. On completion of this module the student should be able to:-Define and give examples of the major concepts of sequences of real numbers.-Describe and give examples of the relationships between the major concepts of sequences of real numbers.-Prove various results concerning sequences of real numbers.-Describe and apply the Axiom of Completeness.-Define and describe the concepts of countable and uncountable sets.-Test a given series for convergence.-Find the interval of convergence of a power series.-Find the Taylor series generated by a given function. Pre-Requisite : Intro to Analysis (E&F) (MATH10130), Advanced Calculus (E&F) (MATH10140), Calculus I (MST10010), Calculus II (MST10020)

MATH 34810 Honors Algebra III (3-5 Credit Hours)
The modern axiomatic approach to mathematics is demonstrated in the study of the fundamental theory of abstract algebraic structures. Group theory, subgroups, generators, Lagrange's theorem. Normal subgroups, homomorphisms, isomorphism theorems. Ring theory, integral domains. Ideals, homomorphisms and isomorphism theorems. Polynomial rings, Euclidean algorithm, fields of fractions

MATH 34820 Honors Algebra IV (3-5 Credit Hours)
A comprehensive treatment of groups, polynomials, rings, homomorphisms, isomorphism theorems, field theory, and Galois theory. The course stresses careful mathematical definitions and emphasizes the proofs of the standard theorems of the subject.
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

MATH 34850 Honors Analysis I (3-5 Credit Hours)
Taught at Oxford University Year Long Program Budapest course description: The course provides an introduction to functional analysis. Only some knowledge of calculus and linear algebra is assumed. As time permits at the end of the semester, we shall have a look at unbounded linear operators and applications to PDE theory.

MATH 34860 Honors Analysis II (3-4 Credit Hours)
Required of honors mathematics majors. An advanced course in mathematical analysis in one and several variables. Topics include an axiomatic formulation of the real and complex number systems, compactness, connectedness, metric spaces, limits, continuity, infinite sequences and series, differentiation, the Riemann-Stieltjes integral, the Stone-Weierstrass theorem, the implicit function theorem, differential forms, partitions of unity, simplexes and chains, and Stokes' theorem.

MATH 36800 Introduction to Math Research (1-10 Credit Hours)
This is a course where we will examine a number of different problems or big theorems from a variety of different fields of mathematics. Through the semester we will work through a book which covers in each chapter a different problem from a different area of mathematics, and students will read material independently and present to each other in weekly meetings. The style of the work for the course will mimic a directed reading or undergraduate research in mathematics. Any student who wants to know more about what math research might look like, and who wants to learn about various fields of mathematics. Ideally students taking this course will have had either MATH 10850, MATH 10860, MATH 20610 or MATH 20630 already, but exceptions can be made. Ideally this course would be a precursor to future directed readings or a senior thesis. Students interested in this class should contact the mathematics department for more information.

MATH 40210 Basic Combinatorics (3 Credit Hours)
Combinatorics is the study of objects that are fundamentally discrete (made up of distinct and separated parts) as opposed to continuous. For example, instead of studying differential equations to see how a system evolves as time passes continuously, we study recurrence relations to see how some quantity changes as time increments unit by unit# in place of the functions on the real line studied in analysis, combinatorics looks at functions on a finite set. Combinatorics has been increasing in importance in recent decades, in part because of the advent of digital computers (which operate and store data discretely), and in part because of the recent ubiquity of large discrete networks (social, biological, ecological, ...). Typical objects studied in combinatorics include graphs (networks consisting of nodes, some pairs of which are joined), permutations (arrangements of distinct objects in various different orders), and finite sets and their subsets. There are many aspects of combinatorics, such as enumerative, structural (e.g., when is it possible to travel around a network, visiting each edge once and only once?), extremal (e.g., if you know which pairs of people in a class don't like each other, what's the smallest number of groups the class can be broken up into, with no two enemies together in a group?), and algorithmic (e.g., if you know the cost of connecting each possible pair of a set of towns, how can you find the most economical network that fully connects up the towns?). In this course, we will explore each of these aspects of combinatorics, and maybe some more as time permits.

MATH 40390 Numerical Analysis (3 Credit Hours)
An introduction to the numerical solution of ordinary and partial differential equations. Topics include the finite difference method, projection methods, cubic splines, interpolation, numerical integration methods, analysis of numerical errors, numerical linear algebra and eigenvalue problems, and continuation methods.
Prerequisites: (MATH 20750 or MATH 20860 or MATH 30650) and (MATH 20610 or MATH 20810) and (ACMS 20210 or CSE 20232 or CSE 20211)

MATH 40480 Complex Variables (3 Credit Hours)
An introduction to the theory of functions of one complex variable. Topics include analytic functions, Cauchy integral theorems, power series, Laurent series, poles and residues, applications of conformal mapping, and Schwarz-Christoffel transformations.
Prerequisites: MATH 20550 or MATH 10093 or MATH 20850

MATH 40510 Intro to Algebraic Geometry (3 Credit Hours)
Algebraic Geometry is the study of systems of polynomial equations and their vanishing loci. It has important components that lie in the realm of geometry, of algebra and of computation (among others) and countless applications. This course tries to give a flavor of these different aspects of the field and how they fit together. Indeed, much of the fascination of this subject comes from the myriad ways in which arguments squarely in one realm give surprising consequences that fall squarely in a different realm.
Prerequisites: MATH 30710 or MATH 30810

MATH 40520 Theory of Numbers (3 Credit Hours)
An introduction to elementary number theory. Topics include the Euclidean algorithm, congruencies, primitive roots and indices, quadratic residues, quadratic reciprocity, distribution of primes, and Waring's problem.
Prerequisites: (MATH 20820 or MATH 30710) and MATH 30750

MATH 40570 Mathematical Methods in Financial Economics (3 Credit Hours)
An introduction to financial economic problems using mathematical methods, including the portfolio decision of an investor and the determination of the equilibrium price of stocks in both discrete and continuous time, will be discussed. The pricing of derivative securities in continuous time including various stock and interest rate options will also be included. Projects reflecting students' interests and background are an integral part of this course.
Prerequisites: (MATH 30530) and (MATH 20750 or MATH 30650) and (MATH 30750 or MATH 30850) or (FIN 30600) or (FIN 70670)

MATH 40720 Topics in Algebra (3 Credit Hours)
This course will provide an introduction to partially ordered sets ("posets") and lattices, which are mathematical notions based on the idea of an "ordering" of a collection of objects, and which have both broad relevance in mathematics and many applications to other fields including computer science, social science, sports and games, philosophy and logic. The first part of the course will discuss basic properties, examples and special types of posets and lattices, their special elements and subsets, their visualization by Hasse diagrams, constructions involving them, and special types of functions between them. The second part of the course will treat a variety of special topics from amongst formal concept analysis, Galois connections, representations of lattices, congruences and quotient lattices, and fixed point theory. The course will use the text "Introduction to lattices and order" by Davey and Priestly. Formal prerequisites for the course are Math 20630 (Introduction to mathematical reasoning) or 10850 (Honors Calculus I) or consent of the instructor. Students, especially non-math majors, who are potentially interested in the course but who lack its formal prerequisites are encouraged to contact the instructor to determine if taking it would be reasonable in their case.
Prerequisites: MATH 10850 or MATH 20630

MATH 40730 Mathematical and Computational Modeling in Biology and Physics (3 Credit Hours)
Introductory course on applied mathematics and computational modeling with emphasis on modeling of biological problems in terms of differential equations and stochastic dynamical systems. Students will be working in groups on several projects and will present them in class in the end of the course.
Prerequisites: (MATH 20750 or MATH 30650 or ACMS 20750) and ACMS 20210

MATH 40740 Topology (3 Credit Hours)
Topology is concerned with the question of whether one geometric object can be continuously deformed into another. The course will introduce some of the basic objects of study in topology: knots and surfaces. A knot is an entangled circle in 3-dimensional space. A surface is the boundary of a solid, smooth object in space, such as a basketball, a pretzel or a mug. Given two knots, can one of them be continuously transformed into the other? Or, can the boundary of a ball gradually be turned into the boundary of a pair of scissors? We will study these topological objects and develop techniques to distinguish and classify them.
Prerequisites: MATH 20630

MATH 40745 Point Set Topology (3 Credit Hours)
The course will introduce the basic concepts of topology as well as some key questions and techniques in the subject. Topics to be covered will include: metric spaces; compact, complete and Hausdorff spaces; cell complexes; deformation retractions; homotopy equivalent spaces. Additional topics may include: fundamental groups and van Kampen's theorem; covering spaces and deck transformations; higher homotopy groups; manifolds; handlebodies and Heegaard splittings; Euler characteristic; space-filling curves; the Brouwer fixed-point theorem, among others.

MATH 40750 Partial Differential Equations (3 Credit Hours)
Partial differential equations (PDE) have long been attracting the interest of a large portion of the scientific community, since they can be employed for modelling a plethora of fascinating phenomena arising in various areas of the sciences such as fluid dynamics, quantum mechanics, mathematical biology and mathematical finance and economics. It is important that such equations are studied rigorously as mathematical objects. On the one hand, this may lead to new mathematical theories while on the other, it helps other scientists to better understand the validity of the models and ultimately the underlying physical phenomena. This course provides an introduction of the basic ideas and techniques that have been proved useful for studying the basic properties of PDE and whenever possible for solving them analytically or numerically. Also, it prepares students for taking interdisciplinary courses using PDE, like Mathematical Methods in Financial Economics (Math 40570), and graduate PDE courses.
Prerequisites: (MATH 20750 or MATH 20820 or MATH 30650)

MATH 40760 Differential Geometry (3 Credit Hours)
An introduction to differential geometry. Topics include analysis of curves and surfaces in space, the first and second fundamental forms of surfaces, torsion, curvature and the Gauss-Bonnet theorem.
Prerequisites: MATH 20750 or MATH 20860 or MATH 30650

MATH 40910 Topics in Mathematical Logic (3 Credit Hours)
Mathematical proofs are the cornerstone of truth. Proofs verify medical devices and spacecraft work properly. They help establish guilt or innocence. The theme of this class is to explore the notion of proof with certain logical systems with the motivation of understanding mathematical proofs or reasoning. We will study proofs in extended syllogistic logics, propositional logic, other logical systems close to natural language, and first-order logic. We will show some of these systems are complete (every true statement is provable) and decidable (there is an algorithm for deciding truth) and others are not. We will explore what this means. Along the way we will hopefully learn more about how people reason. It would be good to have taken at least one proof-oriented class previously but no knowledge of formal logic is required. Assessment will be done by a combination of weekly sets of short answer questions, some written homework sets, a midterm exam or two and a final project with a presentation.
Prerequisites: MATH 30710 or MATH 30810

MATH 40920 Philosophy of Mathematics (3 Credit Hours)
Philosophical conundrums pervade mathematics, from fundamental questions of mathematical ontology to deep questions of epistemology. What are numbers? What is the nature of infinity? How do or can we come to mathematical knowledge? What are the relations between truth, proof, and meaning? Does every mathematical truth admit of proof? What role do figures play in geometric argument? Do mathematical objects exist that we cannot construct? Can every mathematical question be solved in principle by computation? By what criteria are we to accept or reject mathematical axioms? These are merely a few of the questions we shall consider while exploring various philosophical positions, including platonism, realism, logicism, structuralism, formalism, constructivism, and many others. No specific mathematical knowledge is required for study in this subject, but a stronger mathematical background may enable a deeper understanding. The course is part of the philosophy major, but interested students from mathematics and computer science are welcome and indeed encouraged to participate. Main text: Joel David Hamkins, Lectures on the Philosophy of Mathematics, MIT Press 2021. There will be supplemental readings from the philosophical literature.

MATH 40960 Topics in Geometry or Topology (3 Credit Hours)
Fourier Analysis is one of the fundamental topics of modern mathematics, whose origin lies in the work of Euler and the Bernoulli brothers and their study of the vibrating string. It has, since, become an essential tool in mathematics, physics, engineering, computer science, etc, with applications from PDE to number theory to representation theory to combinatorics. This course will begin with the classical theory of Fourier series followed by an overview of Fourier transforms in one and several variables, with an emphasis on applications. Possible topics include: convolutions and summability kernels - Fejer, Poisson; convergence of Fourier series - Hilbert spaces and mean-square and pointwise convergence; applications; Fourier transform on the line: the Schwartz space; Fourier inversion formula; Plancherel theorem; Poisson summation formula; applications; Fourier transform on R^n.
Prerequisites: (MATH 20610 or MATH 20580) and (MATH 30750 or MATH 10860)

MATH 43900 Problem Solving in Mathematics (1 Credit Hour)
The main goal of this course is to develop problem solving strategies in mathematics.
Course may be repeated.

MATH 44210 Discrete Mathematics I (3,4 Credit Hours)
Recurrence relations and generating functions. Principle of inclusion and exclusion. Ramsey theory. Latin squares. Designs. Finite geometries. Systems of Distinct Representatives. Hall's Condition. Doubly Stochastic Matrices. Systems of Common Representatives. Permanents. Van der Waerden Theorem. Mutually Orthogonal Latin Squares. Projective Planes.

MATH 44480 Complex Variables (3-4 Credit Hours)
This module aims to introduce students to analytic function theory and applications. The topics covered include: analytic functions; Cauchy-Riemann equations; harmonic functions; multivalued functions and the cut plane; singularities; Cauchy's theorem; Laurent series; evaluation of contour integrals; fundamental theorem of algebra; Argument Principle; Rouche's Theorem. IT - Trinity College - Dublin An introduction to Complex Analysis including applying basic theorems and concepts.

MATH 44520 Theory of Numbers (1-5 Credit Hours)
Number theory is one of the oldest parts of mathematics. The aim of this course is to introduce students to some classical and important basic ideas of the subject including the following: The ring of integers; congruences; rings of integers modulo ; the Chinese Remainder Theorem; Wilson's Theorem; Fermat's Little Theorem for prime modulus; Euler's generalization of Fermat's Little Theorem to arbitrary modulus; primitiveroots; quadratic residues modulo primes; quadratic reciprocity; factorisation of large integers; basic version of the RSA encryption method.

MATH 44570 Financial Mathematics (2-4 Credit Hours)
University of Sydney: MATH 3075 - This unit will introduce you to the mathematical theory of modern finance with the special emphasis on the valuation and hedging of financial derivatives, such as: forward contracts and options of European and American style. You will learn about the concept of arbitrage and how to model risk-free and risky securities. Topics covered by this unit include: notions of a martingale and a martingale measure, the fundamental theorems of asset pricing, complete and incomplete markets, the binomial options pricing model, discrete random walks and the Brownian motion, the Black-Scholes options pricing model and the valuation and hedging of exotic options. Students completing this unit have been highly sought by the finance industry, which continues to need graduates with quantitative skills. Lectures in the mainstream unit are held concurrently with those of the corresponding advanced unit. MST 30030 Financial Mathematics at UCD; The aim of "Financial Mathematics" is to introduce to the student to the Black-Scholes model for pricing options. The module opens by looking at various types of options and discussing their properties. The technique of constructing binomial trees to price options (based on the Cox, Ross and Rubenstein paper of 1979) is then discussed in detail. We then study the model of stock price behaviour introduced by Black, Scholes and Merton in 1973, and derive the Black-Scholes model for valuing European call and put options on a non-dividend-paying stock. A brief introduction to probability theory is included in the course.

MATH 44720 Topics in Algebra (3 Credit Hours)
Taught at a host institution. MATH 20260 The Mathematics of Google at UCD; The Google search engine has made accessing information easy and its speed and efficacy amazes people. This module explains how it works. An essential component is the ability to rank information according to its importance, and in Google, this relies on simple algebraic principles. Some companies hire SEOs (search engine optimizers) to try to gain competitive advantage by raising Google's estimate of their importance and the strategies used to achieve, and also to prevent, this. The mathematical areas involved are linear algebra and elementary probability theory. The presentation will in part be based on the book by Amy Langville and Carl Meyer "Google's PageRank and Beyond: The Science of Search Engine Rankings" (Princeton University Press 2006) Course may be repeated.

MATH 44740 Topology (3-5 Credit Hours)
This course introduces the important link between topology and group theory. On the one hand, associated to each space, there is a group, known as its fundamental group. This can be used to solve topological problems using algebraic methods. On the other hand, many results about groups are best proved and understood using topology. For example, presentations of groups, where the group is defined using generators and relations, have a topological interpretation. One of the highlights of the course is the Nielsen-Schreier Theorem, an important, purely algebraic result, which is proved using topological techniques. Learning Outcomes: Students will develop a sound understanding of simplicial complexes, cell complexes and their fundamental groups. They will be able to use algebraic methods to analyse topological spaces and compute the fundamental groups of many spaces, including compact surfaces. They will also be able to address questions about groups using topological techniques. Course Synopsis: Homotopic mappings, homotopy equivalence. Simplicial complexes. Simplicial approximation theorem. The fundamental group of a space. The fundamental group of a circle. Application: the fundamental theorem of algebra. The fundamental groups of spheres. Free groups. Existence and uniqueness of reduced representatives of group elements. The fundamental group of a graph. Groups defined by generators and relations (with examples). Tietze transformations. The free product of two groups. Amalgamated free products. The Seifert-van Kampen Theorem. Cell complexes. The fundamental group of a cell complex (with examples). The realization of any finitely presented group as the fundamental group of a finite cell complex. Covering spaces. Liftings of paths and homotopies. A covering map induces an injection between fundamental groups. The use of covering spaces to determine fundamental groups: the circle again, and real projective n -space. The correspondence between covering spaces and subgroups of the fundamental group. Regular covering spaces and normal subgroups. Cayley graphs of a group. The relationship between the universal cover of a cell complex, and the Cayley graph of its fundamental group. The Cayley 2-complex of a group. The Nielsen-Schreier Theorem (every subgroup of a finitely generated free group is free) proved using covering spaces.

MATH 44760 Differential Geometry (3,4 Credit Hours)
Different ways of thinking about surfaces (also called two-dimensional manifolds) are introduced in this course: first topological surfaces and then surfaces with extra structures which allow us to make sense of differentiable functions (`smooth surfaces'), holomorphic functions (`Riemann surfaces') and the measurement of lengths and areas (`Riemannian 2-manifolds'). These geometric structures interact in a fundamental way with the topology of the surfaces. A striking example of this is given by the Euler number, which is a manifestly topological quantity, but can be related to the total curvature, which at first glance depends on the geometry of the surface. The course ends with an introduction to hyperbolic surfaces modelled on the hyperbolic plane, which gives us an example of a non-Euclidean geometry (that is, a geometry which meets all Euclid's axioms except the axioms of parallels). The candidate will be able to implement the classification of surfaces for simple constructions of topological surfaces such as planar models and connected sums; be able to relate the Euler characteristic to branching data for simple maps of Riemann surfaces; understand the definition and use of Gaussian curvature; know the geodesics and isometries of the hyperbolic plane and their use in geometrical constructions.

MATH 44844 Special Topics (1-5 Credit Hours)
This topical course is intended for students attending international study programs. It is a variable credit hour course, with a maximum of 4 credits per semester, arranged individually for each student. It is a repeatable for credit course. BP - Budapest, Hungary Mathematics of Network Science The aim of the course is to get acquainted with the mathematical foundations of network science including elements of classical graph theory, random graph theory, and random processes on networks. Some applications from biology, sociology, economics, and other fields will be discussed. The course will be provided in two hours of lectures, followed by two hours of practical sessions twice a week. The lectures will be focused on theory, while the practical sessions will focus on programming tutorials and programming assignments, which are intended to be solved and handed in at the end of the session. There will be 6 pen-and-paper homework assignments and one quiz (midterm exam). At the end of the term, students are expected to select a paper from a list provided by the instructor, and give a short 15 minute presentation about it.
Course may be repeated.

MATH 46800 Directed Readings (1-10 Credit Hours)
Consent of director of undergraduate studies in mathematics is required.
Course may be repeated.

MATH 48800 Undergraduate Research (0-4 Credit Hours)
This course offers students the opportunity to study and do research on a topic of their interest with faculty members of Mathematics department. It is a variable credit hour course, with a maximum of 4 credits per semester, arranged individually for each student. This is a repeatable for credit course.
Course may be repeated.

MATH 48900 Thesis (1-10 Credit Hours)
Seniors in the mathematics program have the option of writing a senior thesis on a more advanced subject than is provided in the normal undergraduate courses. A program of readings on the topic must be begun with a faculty advisor by the spring semester of the junior year.
Course may be repeated.