

# MATHEMATICS

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Chairperson: Hengguang Li

<https://clas.wayne.edu/math/>

The courses offered by the Department of Mathematics serve several purposes; they supply the mathematical preparation necessary for students specializing in the physical, life or social sciences, in business administration, in engineering, and in education; they provide a route by which students may achieve a level of competence to do research in any of several special mathematical areas; they allow students to prepare themselves for work as mathematicians and statisticians in industry and government; and they give an opportunity to all inquisitive students to learn something about modern mathematical ideas.

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CANDELORI, LUCA: Ph.D. and M.Sc., McGill University; A.B., Harvard University; Assistant Professor

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ISAKSEN, DANIEL: Ph.D., M.S., University of Chicago; B.A., University of California, Berkeley; Professor

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KLEIN, JOHN R.: Ph.D., M.A., Brandeis University; B.A., Northwestern University; Professor

KONG, XIAOLI: Ph.D., M.S., University of Kentucky; Assistant Professor

KUMAR, ROHINI: Ph.D., University of Wisconsin-Madison; M.S., B.S., Bangalore University; Associate Professor

LEBIEDZIK, CATHERINE: Ph.D., M.A., University of Virginia; B.S., Pennsylvania State University; Associate Professor

LI, HENGGUANG: Ph.D., Pennsylvania State University; B.S., Peking University; Professor and Chair

MAHABIR, NARESH: M.A., B.A., Wayne State University; Associate Professor of Teaching

MAKAR-LIMANOV, LEONID: Ph.D., M.S., Moscow State University; Professor

MARTELL, RAUL: M.A., B.A., Wayne State University; Assistant Professor of Teaching

MENALDI, JOSE: M.S., University of Texas-Arlington; B.S., Michigan Tech University; Professor

MORDUKHOVICH, BORIS S.: Ph.D., M.S., Byelorussian State University; Distinguished Professor

NAZELLI, CHRISTOPHER: M.A., B.A., Wayne State University; Associate Professor of Teaching

OKOH, FRANK: Ph.D., M.S., Queen's University; B.S., Imperial College of Science and Technology; Professor

PACHECO, OMAR M.: B.S., Wayne State University; Assistant Professor of Teaching

PINEAU, RICHARD: M.P.A., G.C.E.D., M.A., B.A., Wayne State University; Associate Professor of Teaching

SALCH, ANDREW: Ph.D., M.A., University of Rochester; B.S. Portland State University; Associate Professor

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ZHANG, SHENG: Ph.D., Pennsylvania State University; Ph.D., Chinese Academy of Sciences; M.S., Xian Jiaotong University; B.S., Northwestern University of China; Associate Professor

ZHANG, ZHIMIN: Ph.D., University of Maryland at College Park; M.S., B.S., University of Science and Technology; Professor

- Actuarial Mathematics (B.A.) (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/actuarial-mathematics-ba/>)
- Mathematical Economics (B.A.) (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/mathematical-economics-ba/>)
- Mathematics (B.A.) (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/mathematics-ba/>)
- Mathematics (B.S.) (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/mathematics-bs/>)

- Statistics (B.S.) (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/statistics-bs/>)
- Mathematics Minor (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/mathematics-minor/>)
- Statistics Minor (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/statistics-minor/>)
- Advanced Courses for Non-Majors (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/advanced-courses-non-majors/>)

*For details on Mathematics prerequisite requirements, please see the Mathematics Placement Information (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/placement/>) section of this bulletin, or the Mathematics Placement Exam (<http://testing.wayne.edu/register/math-placement-exam.php>) information provided by the Office of Testing, Evaluation and Research Services.*

## Mathematics

### **MAT 1000 Mathematics in Today's World Cr. 3**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
An exploration of current applications of mathematics, such as gerrymandering, consumer mathematics, cryptography, identification numbers, art, music, statistical design, optimal decision making, and risk assessment. Offered Every Term.

**Restriction(s):** Enrollment is limited to Undergraduate level students.

### **MAT 1010 Beginning Algebra Cr. 3,5**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
Review of arithmetic, integers, fractions, decimals, percents, ratios. Algebra: solving equations and inequalities, algebraic expressions, graphing, problem solving. Offered Every Term.

### **MAT 1070 College Algebra Cr. 5**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
A college algebra course with emphasis on functions. Topics include: properties of the real number system, equations and inequalities, lines, graphs, algebra of functions, modeling, exponents, logarithms, systems of equations and conic sections, and introduction to trigonometry if time allows. Warning: This course may not be equivalent to college algebra courses at other institutions. Therefore, this course in conjunction with a trigonometry course taken elsewhere is not sufficient preparation for MAT 2010 (Calculus I). Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Some sections are offered by the Rising Scholars Program (RSP). These sections require departmental approval and must be taken with MAT 1075, a two-hour workshop. Email [emergingscholars@wayne.edu](mailto:emergingscholars@wayne.edu) for more information regarding the RSP sections. Offered Every Term.

**Prerequisites:** MAT 0993 with a minimum grade of CNC (must be taken at WSU), MAT Permit to Reg ACT/SAT with a test score minimum of 2-4, or Math Permit to Reg - (L1-L4) with a test score minimum of 2-4

### **MAT 1075 Problem Solving for College Algebra Cr. 2**

Students work collaboratively on challenging problems related to "College Algebra." Communication skills are taught through group discussions and journal writing. Serving students in the Rising Scholars Program, students are immersed in an environment that promotes a sense of community and the habits of success. This course must be taken with a Rising Scholars Program (RSP) MAT 1070 section. Email [emergingscholars@wayne.edu](mailto:emergingscholars@wayne.edu) for more information. Offered Fall, Winter.

**Corequisite:** MAT 1070

### **MAT 1110 Mathematics for Elementary School Teachers I Cr. 3**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
Problem solving, sets, functions, reasoning, number theory, whole numbers, integers, fractions, decimals. Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Offered Fall, Winter.

**Prerequisites:** MAT 1050-6999 with a minimum grade of C- (must be taken at WSU), MAT 0995 with a minimum grade of CNC (must be taken at WSU), Math Permit to Reg - (L1-L4) with a test score minimum of 3-4, or MAT Permit to Reg ACT/SAT with a test score minimum of 3-4

### **MAT 1120 Mathematics for Elementary School Teachers II Cr. 3**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
Statistics, probability, geometry, and measurement. Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Offered Fall, Winter.

**Prerequisites:** MAT 1110 with a minimum grade of C- (must be taken at WSU), MAT Permit to Reg ACT/SAT with a test score minimum of 3-4, or Math Permit to Reg - (L1-L4) with a test score minimum of 3-4

### **MAT 1400 Artificial Intelligence and the Conscious Mind Cr. 3**

**Satisfies General Education Requirement:** Cultural Inquiry  
This course provides an introduction to philosophical and scientific thinking about Artificial Intelligence (AI). The public release of Large Language Models (LLMs) such as ChatGPT and relatives has created both high hopes for the future and also deep worries. Generative AI systems such as LLMs now display nearly human-level abilities at tasks that would require genuine intelligence and consciousness if performed by humans. But what are AIs really doing in performing these tasks? Are AIs intelligent, understanding, conscious? Could they be in the near future? Our overall aim in this course is to gain some understanding of the workings of neural networks, machine learning, and AI, to combine that with an understanding of philosophical and cognitive scientific approaches to understanding mentality and consciousness, and thereby to take a few baby steps toward putting together answers to these important questions. Offered Yearly.

**Equivalent:** PHI 1400

### **MAT 1800 Elementary Functions Cr. 4**

**Satisfies General Education Requirement:** Quantitative Experience Comp  
Basic definition and concept of function. Definitions, properties and graphs of polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions. Only two degree credits after MAT 1500. Students in the Emerging Scholars Program must also enroll in the accompanying problem-solving workshop: MAT 1990, for a total of six credits. Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Offered Every Term.

**Prerequisites:** MAT 1070 with a minimum grade of C- (must be taken at WSU), MAT Permit to Reg ACT/SAT with a test score minimum of 3-4, or Math Permit to Reg - (L1-L4) with a test score minimum of 3-4

### **MAT 1990 Precalculus Workshop Cr. 2**

Students work cooperatively in groups to solve challenging problems related to precalculus. Learning is through discovery rather than by lecture. Offered Every Term.

**MAT 2010 Calculus I Cr. 4**

**Satisfies General Education Requirement:** Quantitative Experience Comp Calculus as the study of change. Definitions, concepts, and interpretations of the derivative and the definite and indefinite integrals; differentiation, integration, applications. No credit after former MAT 1510. Students in the Emerging Scholars Program must also enroll in the accompanying problem-solving workshop: MAT 2110, for a total of six credits. Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Offered Every Term.

**Prerequisites:** MAT 1800 with a minimum grade of C-, MAT Permit to Reg ACT/SAT with a test score minimum of 4, or Math Permit to Reg - (L1-L4) with a test score minimum of 4

**MAT 2020 Calculus II Cr. 4**

**Satisfies General Education Requirement:** Quantitative Experience Comp Review definition of definite integral and fundamental theorem of calculus. Techniques of integration; approximate integration; improper integrals; applications of integration. Sequences and series. Approximating functions by polynomials and Taylor series. Students in the Emerging Scholars Program must also enroll in the accompanying problem-solving workshop: MAT 2120, for a total of six credits. Prerequisites are subject to specific conditions. Refer to the Mathematics Placement Information page referenced at the top of the Mathematics course listings in the University Bulletin. Offered Every Term.

**Prerequisites:** MAT 2010 with a minimum grade of C-

**MAT 2030 Calculus III Cr. 4**

Multivariable calculus with applications. Vectors and vector functions in two and three dimensions; functions of several variables; differentiation; integration; vector calculus. Offered Every Term.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**MAT 2110 Calculus Workshop I Cr. 2**

Students work cooperatively in groups to solve challenging problems related to calculus. Learning is through discovery rather than by lecture. Offered Every Term.

**Prerequisites:** MAT 2010 with a minimum grade of C- (may be taken concurrently)

**MAT 2120 Calculus Workshop II Cr. 2**

Students work cooperatively in groups to solve challenging problems related to calculus. Learning is through discovery rather than by lecture. Offered Winter.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**MAT 2150 Differential Equations and Matrix Algebra Cr. 4**

Differential equations and applications; basic operations of matrices from linear algebra. Only one degree credit after MAT 2350. Offered Every Term.

**Prerequisites:** MAT 2030 with a minimum grade of C-

**MAT 2250 Elementary Linear Algebra Cr. 3**

Topics include: systems of linear equations, matrices, vector spaces, basis, dimension, inner products, linear transformations and eigenvalues. Applications presented. Offered Every Term.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**MAT 2300 Mathematical Epidemiology Cr. 3**

This is a first course in the mathematical modeling of infectious diseases. The course starts with historical, biological, and mathematical background. We introduce basic epidemic models (SIR, SIS, SIRS) first without and then with demographics, and study the properties of these models. We will learn about more complex epidemic models (SEIR, etc.) and how to validate models using real-world data. If time permits, other topics may include: vector-borne disease models, global stability, or control strategies. Offered Yearly.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**MAT 2350 Elementary Differential Equations Cr. 3**

Topics include: first order equations, higher order linear equations, Laplace transforms, linear systems. Applications presented throughout the course. No degree credit after MAT 2150. Offered Yearly.

**Prerequisites:** MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

**MAT 2500 Fundamentals of Mathematics and Proof-Writing Cr. 3**

This course is a writing-intensive introduction to mathematical proofs, where students will learn to read and write mathematics in definition-theorem-proof format. The mathematical content of the course is elementary set theory (finite and infinite sets, cardinality, Zorn's Lemma and the Axiom of Choice, the Continuum Hypothesis) and elementary analysis (metric spaces and the real numbers). Offered Yearly.

**Prerequisites:** MAT 2010 with a minimum grade of C-

**MAT 2860 Discrete Mathematics Cr. 3**

Foundations of mathematics: logic and mathematical reasoning; sets, functions, sequences; the integers and the Euclidean algorithm; induction, recursive definitions and recurrence relations; graphs. Combinatorics. Graph theory. Boolean algebra. No credit after former MAT 1860 or 1870. Offered Yearly.

**Prerequisites:** MAT 2010 with a minimum grade of C-

**MAT 3430 Applied Differential and Integral Calculus Cr. 4**

Limits, derivatives, applications of derivatives, definite integrals and their applications, and trigonometric functions. No degree credit in College of Liberal Arts and Sciences. Offered Every Term.

**Prerequisites:** MAT 1800 with a minimum grade of C-

**Equivalent:** ET 3430

**MAT 3450 Applied Calculus and Differential Equations Cr. 4**

Continuation of MAT/ET 3430, including logarithmic and exponential functions, first and second order ordinary differential equations, vectors, polar coordinates, Laplace transforms, Taylor series, and Fourier series. No degree credit in College of Liberal Arts and Sciences. Offered Every Term.

**Prerequisites:** ET 3430 with a minimum grade of C- or MAT 2010 with a minimum grade of C-

**Equivalent:** ET 3450

**MAT 3800 Contemporary Topics in Mathematics Cr. 3**

The content of this course will vary from semester to semester. It will cover topics of current interest that are not part of other mathematics courses. Offered Intermittently.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**Repeatable for 12 Credits**

**MAT 4990 Directed Study: Honors Program Cr. 1-4**

Offered Intermittently.

**Repeatable for 8 Credits**

**MAT 5040 Elementary Abstract Algebra Cr. 4**

This is an introduction to some of the main ideas of number theory and abstract algebra. The course also serves to introduce students to the uses and benefits of abstraction, and to the construction of airtight logical arguments. We start with a careful investigation of familiar number systems: the natural numbers, the integers, the rationals, the reals and the complex numbers. We then proceed to generalize these ideas to consider polynomial rings and fields. Offered Fall.

**Prerequisites:** MAT 2010 with a minimum grade of C- and 1 of (MAT 2500 with a minimum grade of C- or MAT 2860)

**MAT 5070 Elementary Analysis Cr. 4**

Topics include: the real numbers, cardinality, sequences, limits, continuity, uniform continuity, differentiation, integration. Offered Fall, Winter.

**Prerequisites:** MAT 2030 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

**MAT 5100 Numerical Methods I Cr. 3**

Numerical errors; solutions of nonlinear equations; polynomial interpolation; numerical approximation; numerical integration and differentiation; numerical solutions of systems of linear equations; numerical solutions of ordinary differential equations. Offered Fall.  
**Prerequisites:** MAT 2030 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, and (BE 1500 with a minimum grade of C- or (CSC 1100 with a minimum grade of C- and CSC 1101 with a minimum grade of C-))

**MAT 5120 Abstract Algebra for Middle School Teachers Cr. 3**

Topics from elementary abstract algebra underpinning middle school mathematics curriculum; historical connections; role of abstraction and proof in mathematics. No credit towards major in mathematics or secondary mathematics. Offered Every Other Year.  
**Prerequisites:** MAT 1120 with a minimum grade of C- and MAT 1800 with a minimum grade of C-  
**Equivalent:** MAE 5120

**MAT 5180 Geometry for Middle School Teachers Cr. 3**

Development of Euclidean geometry as a mathematical system; related historical topics; introduction to other geometries; selected topics such as transformations and tessellations. No credit toward a major or minor for secondary mathematics teaching. Offered Every Other Year.  
**Prerequisites:** MAT 1110 with a minimum grade of C- and MAT 1120 with a minimum grade of C-  
**Equivalent:** MAE 5100

**MAT 5190 Number Theory for Middle School Teachers Cr. 3**

Topics from elementary theory of numbers which underlie middle school mathematics; historical connections; role of abstraction and proof in mathematics. No credit toward a major or minor for secondary mathematics teaching. Offered Every Other Year.  
**Prerequisites:** MAT 1800 with a minimum grade of C- or MAT 1120 with a minimum grade of C-  
**Equivalent:** MAE 5110

**MAT 5210 Advanced Calculus Cr. 4**

Functions of many variables; limits, continuity; differentiation, mean value theorems; implicit and inverse function theorems; extremal problems, Lagrange multipliers; fixed-point methods; Taylor series; Fourier series, uniform convergence; improper integrals. Offered Every Other Winter.  
**Prerequisites:** MAT 2150 with a minimum grade of C-, MAT 2350 with a minimum grade of C-, or (MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-)

**MAT 5220 Partial Differential Equations Cr. 4**

Partial differential equations of mathematical physics; review of second-order Linear ODEs with constant coefficients; method of separation of variables; Fourier series; Sturm-Liouville eigenvalue problems; boundary-value problems; method of eigenfunction expansion. Optional topics include Green's functions, solutions by Fourier transform, and method of characteristics. Offered Every Other Fall.  
**Prerequisites:** MAT 2150 with a minimum grade of C-, MAT 2350 with a minimum grade of C-, or (MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-)

**MAT 5230 Complex Variables and Applications Cr. 4**

Cauchy-Riemann equations; elementary functions; mappings by elementary functions; the Cauchy integral formula; Morera's theorem; Taylor series; Laurent series; residues and poles; conformal mappings. Optional topics: improper integrals, the Schwarz-Christoffel transformations; potential theory; applications to differential and integral equations. No credit after MAT 6600. Offered Every Other Winter.  
**Prerequisites:** MAT 2150 with a minimum grade of C-, MAT 2350 with a minimum grade of C-, or (MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-)

**MAT 5280 Methods of Differential Equations Cr. 3**

Linear nth order differential equations; linear systems of differential equations (constant and periodic coefficients); oscillation and comparison theorems for second order differential equations; boundary value problems; stability theory (Liapunov's direct method and frequency domain stability criteria); asymptotic solutions; autonomous non-linear systems; classification of singularities. Offered Fall.  
**Prerequisites:** MAT 2150 with a minimum grade of C- or MAT 2350 with a minimum grade of C-

**MAT 5350 Logical Systems I Cr. 4**

Metaresults concerning formal systems of sentential and first-order logics; soundness, completeness; independence of axioms; introduction to recursive functions; formalization of elementary arithmetic; discussion of Godel's incompleteness theorem and Church's Theorem. Offered Every Other Year.  
**Prerequisites:** MAT 5600 with a minimum grade of C-, PHI 2850 with a minimum grade of C-, PHI 2860 with a minimum grade of C-, PHI 5050 with a minimum grade of C-, or MAT 5420 with a minimum grade of C-  
**Equivalent:** PHI 5350

**MAT 5400 Elementary Theory of Numbers Cr. 3**

Primes and the Fundamental Theorem of Arithmetic; greatest common divisor, least common multiple, Euclidean Algorithm; congruences, theorems of Fermat, Wilson and Euler; arithmetic functions; linear Diophantine equations; quadratic congruences and the Law of Quadratic Reciprocity. Optional topics include: applications to cryptography, perfect numbers, primitive roots and indices, Fibonacci numbers, Pythagorean triples, sums of squares, continued fractions. Offered Yearly.  
**Prerequisites:** MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

**MAT 5410 Applied Linear Algebra Cr. 4**

Gaussian elimination, vector spaces, the four fundamental subspaces, orthogonality, least squares approximation, determinants, eigenvalues and eigenvectors, positive definite matrices, singular value decomposition, linear transformations, complex matrices. Applications such as differential and difference equations, Markov processes, graphs and networks, Fourier series, computer graphics, numerical linear algebra. Offered Winter.  
**Prerequisites:** MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

**MAT 5420 Algebra I Cr. 4**

Abstract concepts: sets, mappings, equivalence relations, induction, general methods of proof. Group theory: groups, subgroups, cyclic groups, direct products, cosets, Lagrange's Theorem, quotient groups, homomorphisms, permutation groups. Rings and fields (basic definitions). Only two credits apply after either MAT 6170 or 6180; no credit after both MAT 6170 and 6180. Offered Fall, Winter.  
**Prerequisites:** MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

**MAT 5430 Algebra II Cr. 4**

Group theory continued: Sylow Theorems, finite abelian groups. Ring theory: rings, integral domains, fields of quotients, homomorphisms, ideals, quotient rings, P.I.D.s, U.F.D.s, polynomial rings. Advanced topics in linear algebra: canonical forms. Field theory: extensions, splitting fields, finite fields, geometric constructions. Offered Fall, Winter.  
**Prerequisites:** MAT 5420 with a minimum grade of C-



**MAT 5530 Elementary Differential Geometry and its Applications Cr. 3**

Introduction to the differential geometry of curves and surfaces in three-dimensional space. Curvature, torsion, Frenet formulas, fundamental theorem of space curves. Gauss and mean curvature, asymptotic and principal curves, geodesics, Gauss-Bonnet theorem. Applications such as pursuit curves, roulettes, brachistochrones, precession of Foucault's pendulum, design of packaging machines, shapes and soap films. Offered Intermittently.

**Prerequisites:** MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

**MAT 5540 Topological Data Analysis Cr. 3**

Application of topological methods to reveal structure in data that are not visible by classical statistical methods. Basic ideas in topology, including topological spaces, continuous functions, homeomorphisms, simplicial complexes, simplicial homology, and the Vietoris-Rips complex. Use of computer software to calculate persistent homology of data sets from the applied sciences and elsewhere. Practical data analysis tools for mathematical sciences, as well as for engineering, physics, biology, medicine, economics, sociology, and any other subject in which experimental data is produced and analyzed. Offered Winter.

**Prerequisites:** MAT 2250 with a minimum grade of C-

**MAT 5600 Introduction to Analysis I Cr. 4**

Completeness, convergence, compactness, connectedness and continuity in the context of metric spaces; applications to differential calculus. Offered Fall, Winter.

**Prerequisites:** MAT 5070 with a minimum grade of C-

**MAT 5610 Introduction to Analysis II Cr. 3**

Integration, point-wise and uniform convergence of sequences and series of functions; power series; introduction to analytic functions; Fourier series; possible additional topics. Offered Fall, Winter.

**Prerequisites:** MAT 5600 with a minimum grade of C-

**MAT 5700 Introduction to Probability Theory Cr. 4**

Probability spaces; combinatorial analysis; independence and conditional probability; discrete and continuous random variables including binomial, Poisson, exponential and normal distributions; expectations; joint, marginal and conditional distribution functions; law of large numbers; central limit theorems. Offered Fall, Winter.

**Prerequisites:** MAT 2030 with a minimum grade of C-

**MAT 5710 Introduction to Stochastic Processes Cr. 3**

Non-measure-theoretic introduction to the theory of stochastic processes and its applications, with emphasis on Markov processes in both discrete and continuous time, the Poisson process, and Brownian motion. Offered Yearly.

**Prerequisites:** 2 of MAT 5700 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

**MAT 5740 The Theory of Interest Cr. 3**

Concrete problems used to explore concepts in the theory of interest, including measurement of interest, annuities, yield rates, amortization, bonds, and stochastic approaches. Students prepare for the actuarial examination FM/2. Offered Yearly.

**Prerequisites:** MAT 2020 with a minimum grade of C-

**MAT 5750 Mathematics of Finance Cr. 3**

Topics to be covered include: financial markets, binomial models, stocks and options, Black-Scholes formula, hedging, bond models and interest rate options, and computational methods for bonds. Offered Winter.

**Prerequisites:** (1 of (MAT 2150 or MAT 2350) and MAT 5700 with a minimum grade of C-)

**MAT 5770 Mathematical Models in Operations Research Cr. 3**

Deterministic and probabilistic mathematical modeling of real-world problems. Linear and nonlinear programming; Markov chains; queuing theory; inventory models; Markov decision processes. Offered Yearly.

**Prerequisites:** MAT 2030 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, and MAT 5700 with a minimum grade of C-

**MAT 5870 Methods of Optimization Cr. 3**

Introduction to basic mathematical theory and computational methods of optimization; unconstrained and constrained optimization problems; optimality conditions in various optimization problems; numerical methods of optimization. Offered Winter.

**Prerequisites:** MAT 2150 with a minimum grade of C- or MAT 2350 with a minimum grade of C-

**MAT 5890 Special Topics in Mathematics Cr. 3-4**

Material currently of interest to students and faculty. Topics to be announced in Schedule of Classes. Offered Fall, Winter.

**Prerequisites:** MAT 2030 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

**Repeatable for 12 Credits**

**MAT 5990 Directed Study Cr. 1-4**

Undergraduates who elect this course must be mathematics majors of honors caliber. Content will vary to satisfy needs of individual student. Offered Every Term.

**Repeatable for 8 Credits**

**MAT 5992 Teaching Mathematics in College Cr. 1**

Preparation for first semester of teaching in developmental-level mathematics course. Content presentation, test-writing, grading, classroom management, use of technology. Students are videotaped and critiqued. Required of all graduate teaching assistants in Mathematics Department. Offered for S and U grades only. Offered Fall.

**Restriction(s):** Enrollment limited to students with a class of Senior; enrollment is limited to students with a major in Mathematics or Mathematics Honors; enrollment is limited to Graduate or Undergraduate level students.

**MAT 5993 Writing Intensive Course in Mathematics Cr. 0**

**Satisfies General Education Requirement:** Writing Intensive Competency Disciplinary writing assignments under the direction of a faculty member. Must be selected in conjunction with a course designated as a corequisite. See section listing in Schedule of Classes for corequisites available each term. Satisfies the University General Education Writing-Intensive Course in the Major requirement. Required for all majors. Offered Every Term.

**Prerequisites:** AFS 2390 with a minimum grade of C, ENG 2390 with a minimum grade of C, ENG 3010 with a minimum grade of C, ENG 3020 with a minimum grade of C, or ENG 3050 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Undergraduate level students.

**MAT 6130 Discrete Mathematics Cr. 3**

Foundations of mathematics: logic, sets, functions, sequences. The integers. Matrices. Mathematical reasoning: induction, recursive definitions and recurrence relations. Combinatorics. Graph theory. Boolean algebra. No credit after former MAT 1860 or 1870. Not available to Math majors for degree credit. Offered Yearly.

**Prerequisites:** MAT 2010 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the College of Education.

**MAT 6140 Geometry: An Axiomatic Approach Cr. 3**

Foundations: logic, axiom systems, models; Hilbert's axioms; the parallel postulate; Euclidean geometry; non-Euclidean geometries; hyperbolic geometry; philosophical questions. Offered Yearly.

**Prerequisites:** MAT 2500 with a minimum grade of C- or MAT 2860 with a minimum grade of C-

**MAT 6150 Probability and Statistics for Teachers Cr. 4**

Counting techniques, discrete sample spaces and probability, random variables, mean and variance, joint distributions, the binomial and normal distributions, central limit theorem, estimation and hypothesis testing. Not available to Math majors for degree credit. Offered Fall, Winter.

**Prerequisites:** MAT 1800 with a minimum grade of C

**Restriction(s):** Enrollment limited to students in the College of Education.

**MAT 6210 Teaching Geometry, Probability and Statistics, and Discrete Mathematics from an Advanced Perspective Cr. 3**

Historical perspectives, common conceptions and misconceptions, applications, technology, and mathematical connections relative to teaching geometry (including trigonometry), probability and statistics, and discrete mathematics in secondary school. Offered Winter.

**Equivalent:** MAE 6210

**MAT 6300 Mathematical Epidemiology Cr. 3**

This is a first course in the mathematical modeling of infectious diseases. The course starts with historical, biological, and mathematical background. We introduce basic epidemic models (SIR, SIS, SIRS) first without and then with demographics, and study the properties of these models. We will learn about more complex epidemic models (SEIR etc.), and how to validate models using real-world data. If time permits, other topics may include: vector-borne disease models, global stability, or control strategies. No credit will be awarded to students who have previously taken MAT 2300. Graduate students in mathematics should take advanced courses in differential equations instead. Offered Yearly.

**Prerequisites:** MAT 2020 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**MAT 6420 Advanced Linear Algebra Cr. 3**

Vector spaces and linear maps from a basis free perspective. Vector spaces, linear transformations, dual spaces, quotient spaces, inner product spaces, quadratic forms, adjoint operators, normal operators, spectral theorem, Jordan canonical form, trace and determinant. Offered Winter.

**Prerequisites:** MAT 5430 with a minimum grade of C-

**MAT 6480 Introduction to Quantum Computing Cr. 3**

Serves as an introduction to quantum computing and brings together students with different backgrounds in mathematics, physics, chemistry, and computer science to foster interdisciplinary connections in the areas of quantum computing and quantum information. A strong background in linear algebra over the complex numbers as well as differential and integral calculus is required. Familiarity with quantum physics and complexity theory will be helpful, but it is not required. Offered Fall.

**Equivalent:** PHY 6480

**MAT 6500 Topology I Cr. 3**

Topological spaces and continuous functions; connectedness; compactness; product and quotient spaces; metric spaces; Urysohn's lemma; Tietze extension theorem; homotopy; covering spaces and path lifting; the fundamental group and examples; Brouwer fixed point theorem and applications. Offered Fall.

**Prerequisites:** MAT 5430 with a minimum grade of C- or MAT 5610 with a minimum grade of C-

**MAT 6600 Complex Analysis Cr. 2-4**

Complex differentiation; elementary functions; Cauchy's integral theorem; power series; Laurent expansions; singularities; residue theorem; entire and meromorphic functions; Riemann mapping theorem. Offered for three credits only, if student has taken MAT 5230. Offered Winter.

**Prerequisites:** MAT 5430 with a minimum grade of C- or MAT 5610 with a minimum grade of C-

**MAT 6990 Internship in Mathematical Sciences Cr. 1-3**

Experience in industry, or in a research laboratory, or in an institution, using tools from the mathematics curriculum. Students provide a written report based on the internship experience. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment is limited to students in the Department of Mathematics.

**Repeatable for 3 Credits**

## Statistics

**STA 1020 Elementary Statistics Cr. 3**

**Satisfies General Education Requirement:** Quantitative Experience Comp Descriptive statistics, correlation and regression, notions in probability, binomial and normal distributions, testing hypothesis. Offered Every Term.

**STA 2210 Probability and Statistics Cr. 4**

**Satisfies General Education Requirement:** Quantitative Experience Comp Basic probability theory (definition of probability, conditional probability, independence, random variables, expectation and variance, normal distribution, law of large numbers, central limit theorem), descriptive statistics (histograms, scatter plots, box plots, mean, variance, quantiles, empirical rule, z-scores), statistical inference (confidence intervals for mean, t-tests, chi-square tests, linear regression, analysis of variance) and data analysis. Offered Every Term.

**Prerequisites:** MAT 1800 with a minimum grade of C-, MAT 2010-2350 with a minimum grade of C-, MAT Permit to Reg ACT/SAT with a test score minimum of 4, or Math Permit to Reg - (L1-L4) with a test score minimum of 4

**STA 5030 Statistical Computing and Data Analysis Cr. 3**

Computational aspect of statistics and data analysis for advanced undergraduate and beginning graduate students. Topics include descriptive statistics, probability distributions, hypothesis testing, ANOVA, linear regression and logistic regression. Data analysis by use of statistical packages such as R, SAS, Python, SPSS or Minitab. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Fall.

**Prerequisites:** (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, MAT 5700 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

**STA 5800 Introduction to Mathematical Statistics Cr. 4**

A one-semester course for senior undergraduate and master's degree students. Introduction to basic mathematical theory of statistics. Topics include survey sampling, estimation theory, data analysis and sample statistics, testing hypothesis, two sample cases, analysis of variance, regression analysis, Bayesian inference. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Winter.

**Prerequisites:** MAT 5700 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

**STA 5820 Introduction to Data Science Cr. 3**

An applied statistical learning course designed for upper level undergraduate students and graduate students in mathematics and other quantitative fields. Topics include: bias-variance trade-off, regression, classification, cross-validation, bootstrap, model selection, regularization, splines, generalized additive models, tree-based methods, support vector machines, principal component analysis and clustering. Computer implementation will be discussed for each of the methods, and students will run their own data analysis projects. Offered Winter.

**Prerequisite:** STA 5030 with a minimum grade of C or STA 5800 with a minimum grade of C or MAT 5800 with a minimum grade of C

### **STA 5830 Applied Time Series Cr. 3**

Time series models, moving average models, autoregressive models, non-stationary models, and more general models; point estimators, confidence intervals, and forecast in the time domain. Statistical analysis in the frequency domain; spectral density and periodogram. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Intermittently.

**Prerequisites:** (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

### **STA 6830 Design of Experiments Cr. 3**

Randomized blocks; Latin and Graeco-Latin squares; factorial designs; confounding; split plot; fractional replication; balanced incomplete blocks. Offered Intermittently.

**Prerequisites:** (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

### **STA 6840 Applied Regression Analysis Cr. 3**

Multiple linear regression; generalized linear models; random effect models; repeated measurements; mixed effect models; non-parametric additive models. Computer implementation using statistical software R; student project on real data analysis. Offered Fall.

**Prerequisites:** STA 5030 with a minimum grade of C- or STA 5800 with a minimum grade of C-

## **Mathematics Placement Information**

For details on Mathematics course placement, please see the Mathematics Placement Information (<http://bulletins.wayne.edu/undergraduate/college-liberal-arts-sciences/mathematics/placement/>) section of this bulletin, or the Mathematics Placement Exam (<http://testing.wayne.edu/register/math-placement-exam.php>) information provided by the Office of Testing, Evaluation and Research Services.

## **Multiple Majors, Degrees, and Minors within the Mathematics Department**

### **Multiple Majors or Degrees**

If a student wishes to complete more than one major or degree within the Mathematics Department (e.g. majors in Mathematics, Actuarial Mathematics, or Statistics), then each major must have at least 3 unique mathematics or statistics (MAT or STA) courses. This means that at least 3 MAT or STA courses used for each major/degree cannot be used for the other major(s)/degree(s). This includes courses from other departments that are approved by the Mathematics Department to meet a major requirement. Note that university policy states that double majors must either be both Bachelor of Arts or both Bachelor of Science majors. They cannot be one of each. For example, students can elect to do a double major which includes a BA in Actuarial Mathematics and a BA in Mathematics, but they cannot elect to do a double major which includes a BS in Statistics and a BA in Mathematics. On the other hand, students can do a double degree in any configuration they choose.

The Mathematical Economics major is a major jointly administered by the Mathematics Department and the Economics Department and it therefore follows a different set of guidelines. If a student wishes to major in Mathematical Economics and another major or majors within the Mathematics Department, the Mathematical Economics major must include one unique MAT or STA course that is not being used for the

other major(s). This includes courses from other departments that are approved by the Mathematics Department to meet a major requirement.

## **Majors and Minors**

If a student wishes to pursue at least one major and a minor, or two minors, within the Mathematics Department, there must be at least one unique course for each minor. This means that at least one MAT or STA course used for each minor cannot be used for the other minor or major(s). This includes courses from other departments that are approved by the Mathematics Department to meet a major requirement. Students cannot major and minor in Mathematics, nor can they major and minor in Statistics.

## **Secondary Mathematics Teaching**

An excellent option for students who would like to become secondary mathematics teachers is to complete any of the mathematics major concentrations or the B.S. in Statistics, along with teacher certification requirements. Please see a Mathematics Department advisor for more details.

## **Emerging Scholars Program**

The Emerging Scholars Program is a special honors program at the levels of MAT 1800, MAT 2010, and MAT 2020, that features collaborative learning through a challenging corequisite problem-solving workshop attached to the lecture section. Note that students need not be enrolled in the Honors College to take these courses. Each ESP calculus course (MAT 2010 and MAT 2020) carries four honors credits, however, MAT 1800 does not offer honors credits. The Emerging Scholars Program seeks dedicated, hard-working students who want to excel in mathematics. Students who place into the level below MAT 1800 are encouraged to enroll in the Rising Scholars Program sections of MAT 1070 and/or MAT 1010 depending on placement, as preparation for the program. Contact the Emerging Scholars Program at [emergingscholars@wayne.edu](mailto:emergingscholars@wayne.edu) for further information.

### **AGRADE Program (Accelerated Graduate Enrollment)**

Our AGRADE program provides the opportunity for top students to enroll simultaneously in an undergraduate and graduate program. Students can apply a maximum of 16 credits toward both an undergraduate and a graduate degree in the student's major field. Students electing AGRADE programs may expect to complete the bachelor's and master's degrees in five years of full-time study if they take full advantage of the program. There is a GPA requirement and students must apply to the program and complete a plan of work for the masters degree with the masters advisor. For more details about the AGRADE program, email [mathgrad@wayne.edu](mailto:mathgrad@wayne.edu), or visit the Graduate Office of the College of Liberal Arts and Sciences website (<https://clas.wayne.edu/programs/accelerated-graduate-enrollment/>).

## **Senior Rule**

In their last undergraduate semester, Wayne State students with a 3.0 (or above) upper division grade point average have the option of taking a limited number of graduate credits. Graduate credit is awarded only for those courses taken in excess of baccalaureate degree requirements. Undergraduate and graduate courses combined may not exceed sixteen credits for the final semester of baccalaureate degree course work. For more information look under Graduate Admissions (<http://bulletins.wayne.edu/graduate/general-information/admission/>) in the Graduate Bulletin or email [mathgrad@wayne.edu](mailto:mathgrad@wayne.edu).