

# Course Catalog - Spring 2009

## Mathematics

002 **Introductory Algebra** credit: 3 hours.

Methods of elementary algebra, including simplification of algebraic expressions, solving linear and quadratic equations, equations of lines, systems of linear equations, and radicals. Enrollment is restricted. Credit may not be used toward graduation in the College of LAS. Prerequisite: Score on appropriate placement test, or consent of Mathematics Department.

012 **Algebra** credit: 3 hours.

Rapid review of basic techniques of factoring, rational expressions, equations and inequalities; functions and graphs; exponential and logarithm functions; systems of equations; matrices and determinants; polynomials; and the binomial theorem. Students who need both algebra and trigonometry should enroll in MATH 016. Credit is not given for both MATH 012 and MATH 016. Credit not applicable toward graduation in certain curricula. Prerequisite: 1.5 units of high school algebra; 1 unit of high school geometry.

014 **Trigonometry** credit: 2 hours.

Studies degrees and radians, the trigonometric functions, identities and equations, inverse functions, oblique triangles and applications. Credit is not given for both MATH 014 and either MATH 016 or MATH 115. Prerequisite: 1.5 units of high school algebra; 1 unit of high school geometry.

016 **Algebra and Trigonometry** credit: 5 hours.

Unified treatment of algebra and trigonometry. Credit is not given for both MATH 016 and either MATH 012 or MATH 014. Credit not applicable toward graduation in certain curricula. Prerequisite: 1.5 units of high school algebra; 1 unit of high school geometry.

103 **Theory of Arithmetic** credit: 4 hours.

Analyses of the mathematical issues and methodology underlying elementary mathematics in grades K-5. Topics include sets, arithmetic algorithms, elementary number theory, rational and irrational numbers, measurement, and probability. There is an emphasis on problem solving. Priority registration will be given to students enrolled in teacher education programs leading to certification in elementary or childhood education. Prerequisite: MATH 012 or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

115 **Preparation for Calculus** credit: 3 hours.

Reviews trigonometric, rational, exponential, and logarithmic functions; provides a full treatment of limits, definition of derivative, and an introduction to finding area under a curve. Intended for students who need preparation for MATH 220, either because they lack the content background or because they are not prepared for the rigor of a university calculus course. Credit is not given for both MATH 115 and either MATH 014 or MATH 016. Students may not receive credit for MATH 115 if MATH 115 is taken after receiving credit for MATH 220 or MATH 221. Prerequisite: MATH 012 and an adequate ALEKS score.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

117 **Elementary Mathematics** credit: 4 hours.

Analyses of the mathematical issues and methodology underlying elementary mathematics in grades 6-8. Topics include the Real number system and field axioms, sequences and series, functions and math modeling with technology, Euclidean and non-Euclidean geometry, probability and statistics. Priority registration will be given to students enrolled in teacher education programs leading to certification in elementary education. Prerequisite: MATH 012 or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

119 ***Ideas in Geometry*** credit: 3 hours.

General education course in mathematics, for students who do not have mathematics as a central part of their studies. The goal is to convey the spirit of mathematical thinking through topics chosen mainly from plane geometry. Prerequisite: Two units of high school algebra; one unit of high school geometry; or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

124 ***Finite Mathematics*** credit: 3 hours.

Introduction to finite mathematics for students in the social sciences; introduces the student to the basic ideas of logic, set theory, probability, vectors and matrices, and Markov chains. Problems are selected from social sciences and business. Prerequisite: MATH 012 or an adequate ALEKS score.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

125 ***Elementary Linear Algebra*** credit: 3 hours.

Basic concepts and techniques of linear algebra; includes systems of linear equations, matrices, determinants, vectors in n-space, and eigenvectors, together with selected applications, such as Markov processes, linear programming, economic models, least squares, and population growth. Credit is not given for both MATH 125 and any of MATH 225, MATH 410, or MATH 415. Prerequisite: MATH 012 or an adequate ALEKS score.

161 ***Statistics*** credit: 3 hours.

Same as STAT 100. See STAT 100.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

181 ***A Mathematical World*** credit: 3 hours.

Introduction to selected areas of mathematical sciences through application to modeling and solution of problems involving networks, circuits, trees, linear programming, random samples, regression, probability, inference, voting systems, game theory, symmetry and tilings, geometric growth, comparison of algorithms, codes and data management. Prerequisite: Three years of high school mathematics, including two years of algebra and one year of geometry.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

198 ***Freshman Seminar*** credit: 3 hours.

Guides the student in the study of selected topics not considered in standard courses. Prerequisite: Enrollment in the mathematics honors program; consent of department.

199 ***Undergraduate Open Seminar*** credit: 1 to 5 hours.

Approved for both letter and S/U grading. May be repeated.

210 **Theory of Interest** credit: 3 hours.

Study of compound interest and annuities; applications to problems in finance. Prerequisite: MATH 231 or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

213 **Basic Discrete Mathematics** credit: 3 hours.

Beginning course on discrete mathematics, including sets and relations, functions, basic counting techniques, recurrence relations, graphs and trees, and matrix algebra; emphasis throughout is on algorithms and their efficacy. Credit is not given for both MATH 213 and CS 173. Prerequisite: MATH 220 or MATH 221, or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

220 **Calculus** credit: 5 hours.

First course in calculus and analytic geometry; basic techniques of differentiation and integration with applications including curve sketching; antidifferentiation, the Riemann integral, fundamental theorem, exponential and trigonometric functions. Credit is not given for both MATH 220 and either MATH 221 or MATH 234. Prerequisite: MATH 016 or MATH 115; and an adequate ALEKS placement score.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

221 **Calculus I** credit: 4 hours.

First course in calculus and analytic geometry for students with some calculus background; basic techniques of differentiation and integration with applications including curve sketching; antidifferentiation, the Riemann integral, fundamental theorem, exponential and trigonometric functions. Credit is not given for both MATH 221 and either MATH 220 or MATH 234. Prerequisite: An adequate ALEKS placement score; and either one year of high school calculus or a minimum score of 2 on the AB Calculus AP exam.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

225 **Introductory Matrix Theory** credit: 2 hours.

Systems of linear equations, matrices and inverses, determinants, and a glimpse at vector spaces, eigenvalues and eigenvectors. Credit is not given for both MATH 225 and any of MATH 125, MATH 410, or MATH 415. Prerequisite: MATH 220 or MATH 221; or equivalent.

231 **Calculus II** credit: 3 hours.

Second course in calculus and analytic geometry: techniques of integration, conic sections, polar coordinates, and infinite series. Credit is not given for both MATH 231 and MATH 230. Prerequisite: MATH 220 or MATH 221.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

234 **Calculus for Business I** credit: 4 hours.

Introduction to the concept of functions and the basic ideas of the calculus. Credit is not given for both MATH 234 and either MATH 220 or MATH 221. Prerequisite: MATH 012 and an adequate ALEKS score.

This course satisfies the General Education Criteria for a Quant Reasoning I course.

241 **Calculus III** credit: 4 hours.

Third course in calculus and analytic geometry including vector analysis: Euclidean space, partial differentiation, multiple integrals, line integrals and surface integrals, the integral theorems of vector calculus. Credit is not given for both MATH 241 and any of MATH 244, MATH 292, or MATH 380. Prerequisite: MATH 231.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

249 **Honors Supplement** credit: 1 hours.

Supplemental credit hour for honors courses with additional material or special projects. Prerequisite: Concurrent registration in a specially designated honors section and consent of department.

267 **Math Issues National Security** credit: 3 hours.

Applications of mathematics to aspects of physical, biological, and social sciences that affect national security. Same as GLBL 267. Prerequisite: Completion of the Quantitative Reasoning I requirement or consent of instructor.

284 **Intro Differential Systems** credit: 4 hours.

First order differential equations; mathematical models and numerical methods; linear systems and matrices; higher-order linear differential equations; eigenvalues and eigenvectors; linear systems of differential equations; Laplace transform methods. Credit is not given for both MATH 284 and either MATH 285 or MATH 286. Prerequisite: MATH 231 or equivalent.

285 **Intro Differential Equations** credit: 3 hours.

Techniques and applications of ordinary differential equations, including Fourier series and boundary value problems, and an introduction to partial differential equations. Intended for engineering majors and others who require a working knowledge of differential equations. Credit is not given for both MATH 285 and any of MATH 284, MATH 286, MATH 441. Prerequisite: MATH 241.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

286 **Intro to Differential Eq Plus** credit: 4 hours.

Techniques and applications of ordinary differential equations, including Fourier series and boundary value problems, linear systems of differential equations, and an introduction to partial differential equations. Covers all the MATH 285 plus linear systems. Intended for engineering majors and other who require a working knowledge of differential equations. Credit is not given for both MATH 286 and any of MATH 284, MATH 285, MATH 441. Prerequisite: MATH 241.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

290 **Symbolic Computation Lab** credit: 1 hours.

Laboratory component to courses using a symbolic programming package. Prerequisite: Consent of department; concurrent registration in a designated section of a mathematics course with symbolic computation component. May be taken only once for credit.

292 **Vector Calculus Supplement** credit: 2 hours.

Course in multivariable calculus. Topics include gradient, divergence, and curl; line and surface integrals; and the theorems of Green, Stokes, and Gauss. Intended for transfer students whose multivariable calculus course did not include the integral theorems of vector calculus. Credit is not given for both MATH 292 and MATH 241. Prerequisite: Consent of instructor.

299 **Topics in Mathematics** credit: 1 to 4 hours.

Topics course; see Class Schedule or department office for current topics. May be repeated in the same or subsequent semesters to a maximum of 8 hours. Prerequisite: MATH 220 or MATH 221; consent of instructor.

347 **Fundamental Mathematics** credit: 3 hours.

Fundamental ideas used in many areas of mathematics. Topics will include: techniques of proof, mathematical induction, binomial coefficients, rational and irrational numbers, the least upper bound axiom for real numbers, and a rigorous treatment of convergence of sequences and series. This will be supplemented by the instructor from topics available in the various texts. Students will regularly write proofs emphasizing precise reasoning and clear exposition. Credit is not given for both MATH 347 and MATH 348. Prerequisite: MATH 231.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

348 **Fundamental Mathematics-ACP** credit: 4 hours.

Course is identical to MATH 347 except for the additional writing component. Credit is not given for both MATH 348 and MATH 347. Prerequisite: MATH 231 and completion of the campus Composition I general education requirement.

This course satisfies the General Education Criteria for a Advanced Composition, and Quant Reasoning II course.

357 **Numerical Methods I** credit: 3 hours.

Same as CS 357. See CS 357.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

362 **Probability with Engrg Applic** credit: 3 hours.

Same as ECE 313. See ECE 313.

370 **Actuarial Problem Solving** credit: 1 hours.

Methods and techniques of solving problems in actuarial mathematics for advanced students intending to enter the actuarial profession. Approved for S/U grading only. May be repeated in the same or subsequent semesters to a maximum of 4 hours. Prerequisite: Consent of instructor.

380 **Advanced Calculus** credit: 3 hours.

Introductory study of vector calculus and functions of several variables; topics include directional derivatives; Jacobians; change of variables in multiple integrals; maxima and minima; line and surface integrals; theorems of Gauss, Green, and Stokes; infinite series; and uniform convergence. Credit is not given for both MATH 380 and MATH 241. Prerequisite: MATH 242.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

390 **Individual Study** credit: 0 to 3 hours.

Guided individual study of advanced topics not covered in other courses. May be repeated to a maximum of 8 hours. Approved for both letter and S/U grading. Prerequisite: Consent of instructor.

402 **Non Euclidean Geometry** credit: 3 or 4 hours.

Historical development of geometry; includes tacit assumptions made by Euclid; the discovery of non-Euclidean geometries; geometry as a mathematical structure; and an axiomatic development of plane geometry. 4 hours

of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241; MATH 347 or MATH 348, or equivalent; or consent of instructor. This course satisfies the General Education Criteria for a Quant Reasoning II course.

403 ***Euclidean Geometry*** credit: 3 or 4 hours.

Selected topics from geometry, including the nine-point circle, theorems of Ceva and Menelaus, regular figures, isometries in the plane, ordered and affine geometries, and the inversive plane. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241; MATH 347 or 348, or equivalent; or consent of instructor.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

405 ***Teacher's Course*** credit: 3 or 4 hours.

In-depth, advanced perspective look at selected topics covered in the secondary curriculum. Connects mathematics learned at the university level to content introduced at the secondary level. Intended for students who plan to seek a secondary certificate in mathematics teaching. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241; MATH 347 or MATH 348, or equivalent; or consent of instructor.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

406 ***History of Calculus*** credit: 3 or 4 hours.

Examination of the historical origins and genesis of the concepts of the calculus; includes mathematical developments from the ancient Greeks to the eighteenth century. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or equivalent. This course satisfies the General Education Criteria for a Quant Reasoning II course.

408 ***Actuarial Statistics I*** credit: 4 hours.

Same as STAT 408. See STAT 408.

409 ***Actuarial Statistics II*** credit: 4 hours.

Same as STAT 409. See STAT 409.

410 ***Lin Algebra & Financial Apps*** credit: 3 or 4 hours.

Emphasizes techniques of linear algebra and introductory and advanced applications to actuarial science, finance and economics. Topics include linear equations, matrix theory, vector spaces, linear transformations, eigenvalues and eigenvectors and inner product spaces. In addition, current research topics such as modeling, data mining, and generalized linear models are explored. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 410 and MATH 125, MATH 225, or MATH 415. Prerequisite: MATH 241; MATH 210 or FIN 221; or consent of instructor.

412 ***Graph Theory*** credit: 3 or 4 hours.

Examines basic concepts and applications of graph theory, where graph refers to a set of vertices and edges that join some pairs of vertices; topics include subgraphs, connectivity, trees, cycles, vertex and edge coloring, planar graphs and their colorings. Draws applications from computer science, operations research, chemistry, the social sciences, and other branches of mathematics, but emphasis is placed on theoretical aspects of graphs. 4

hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 347 or MATH 348 or equivalent experience or CS 373. This course satisfies the General Education Criteria for a Quant Reasoning II course.

413 ***Intro to Combinatorics*** credit: 3 or 4 hours.

Permutations and combinations, generating functions, recurrence relations, inclusion and exclusion, Polya's theory of counting, and block designs. Same as CS 413. 3 undergraduate hours. 3 or 4 graduate hours. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: MATH 347 or MATH 348 or equivalent experience.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

414 ***Mathematical Logic*** credit: 3 or 4 hours.

Introduction to the formalization of mathematics and the study of axiomatic systems; expressive power of logical formulas; detailed treatment of propositional logical and predicate logic; compactness theorem and Godel completeness theorem, with applications to specific mathematical theories; algorithmic aspects of logical formulas. Proofs are emphasized in this course, which can serve as an introduction to abstract mathematics and rigorous proof; some ability to do mathematical reasoning required. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 347 or MATH 348 or equivalent experience.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

415 ***Applied Linear Algebra*** credit: 3 or 4 hours.

Introductory course emphasizing techniques of linear algebra with applications to engineering; topics include matrix operations, determinants, linear equations, vector spaces, linear transformations, eigenvalues, and eigenvectors, inner products and norms, orthogonality, equilibrium, and linear dynamical systems. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 415 and any of MATH 125, MATH 225, or MATH 410. Prerequisite: MATH 241 or consent of instructor. This course satisfies the General Education Criteria for a Quant Reasoning II course.

416 ***Abstract Linear Algebra*** credit: 3 or 4 hours.

Rigorous proof-oriented course in linear algebra. Topics include determinants, vector spaces over fields, linear transformations, inner product spaces, eigenvectors and eigenvalues, Hermitian matrices, Jordan Normal Form. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or consent of instructor; MATH 347 is recommended.

417 ***Intro to Abstract Algebra*** credit: 3 or 4 hours.

Fundamental theorem of arithmetic, congruences. Permutations. Groups and subgroups, homomorphisms. Group actions with applications. Polynomials. Rings, subrings, and ideals. Integral domains and fields. Roots of polynomials. Maximal ideals, construction of fields. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: Either MATH 416 or one of MATH 410, MATH 415 together with one of MATH 347, MATH 348, CS 373; or consent of instructor.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

418 ***Intro to Abstract Algebra II*** credit: 3 or 4 hours.

Rings of quotients of an integral domain. Euclidean domains, principal ideal domains. Unique factorization in polynomial rings. Fields extensions, ruler and compass constructions. Finite fields with applications. Modules. Structure theorem for finitely generated modules over principal ideal domains. Application to finitely generated

abelian groups and canonical forms of matrices. Introduction to error-correcting codes. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 417 or consent of instructor.

423 **Differential Geometry** credit: 3 or 4 hours.

Applications of the calculus to the study of the shape and curvature of curves and surfaces; introduction to vector fields, differential forms on Euclidean spaces, and the method of moving frames for low-dimensional differential geometry. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

424 **Honors Real Analysis** credit: 3 hours.

A rigorous treatment of basic real analysis via metric spaces. Metric space topics include continuity, compactness, completeness, connectedness and uniform convergence. Analysis topics include the theory of differentiation, Riemann-Darboux integration, sequences and series of functions, and interchange of limiting operations. As part of the honors sequence, this course will be rigorous and abstract. Approved for honors grading. 3 undergraduate hours. Prerequisite: An honors section of MATH 347 or an honors section of MATH 416, and consent of the department.

425 **Honors Advanced Analysis** credit: 3 hours.

A theoretical treatment of differential and integral calculus in higher dimensions. Topics include inverse and implicit function theorems, submanifolds, the theorems of Green, Gauss and Stokes, differential forms, and applications. As part of the honors sequence, this course will be rigorous and abstract. Approved for honors grading. 3 undergraduate hours. Prerequisite: MATH 424 and either MATH 415 or MATH 416, and consent of the department.

426 **Honors Linear Algebra** credit: 2 hours.

Matrix operations, vector spaces, linear transformations, bilinear forms and orthogonality. As part of the honors sequence, this course will be rigorous and abstract. Approved for honors grading. 2 undergraduate hours. Credit is not given for both 426 and any of: MATH 125, MATH 225 or MATH 415. Prerequisite: Consent of department.

427 **Honors Abstract Algebra** credit: 3 hours.

Group theory, counting formulae, factorization, modules with applications to Abelian groups and linear operators. As part of the honors sequence, this course will be rigorous and abstract. Approved for honors grading. 3 undergraduate hours. Credit is not given for both MATH 427 and MATH 417. Prerequisite: Consent of the department is required. Prerequisite courses are either an honors section of MATH 416, or MATH 415 together with an honors section of MATH 347.

428 **Honors Topics in Mathematics** credit: 3 hours.

A capstone course in the Mathematics Honors Sequences. Topics will vary. As part of the honors sequence, this course will be rigorous and abstract. Approved for honors grading. 3 undergraduate hours. May be repeated in the same or separate terms to a maximum of 12 hours. Prerequisite: Consent of the department.

432 **Set Theory and Topology** credit: 3 or 4 hours.

Informal set theory, cardinal and ordinal numbers, and the axiom of choice; topology of metric spaces and introduction to general topological spaces. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 347 or MATH 348 or consent of instructor.

439 ***Philosophy of Mathematics*** credit: 3 or 4 hours.  
Same as PHIL 439. See PHIL 439.

441 ***Differential Equations*** credit: 3 or 4 hours.

Basic course in ordinary differential equations; topics include existence and uniqueness of solutions and the general theory of linear differential equations; treatment is more rigorous than that given in MATH 285. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Credit is not given for both MATH 441 and any of MATH 284, MATH 285, MATH 286. Prerequisite: MATH 241. Recommended: MATH 347 or MATH 348.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

442 ***Intro Partial Diff Equations*** credit: 3 or 4 hours.

Introduces partial differential equations, emphasizing the wave, diffusion and potential (Laplace) equations. Focuses on understanding the physical meaning and mathematical properties of solutions of partial differential equations. Includes fundamental solutions and transform methods for problems on the line, as well as separation of variables using orthogonal series for problems in regions with boundary. Covers convergence of Fourier series in detail. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: One of MATH 284, MATH 285, MATH 286, MATH 441.

444 ***Elementary Real Analysis*** credit: 3 or 4 hours.

Careful treatment of the theoretical aspects of the calculus of functions of a real variable; topics include the real number system, limits, continuity, derivatives, and the Riemann integral. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 444 and MATH 447. Prerequisite: MATH 241; MATH 347 or MATH 348, or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

446 ***Applied Complex Variables*** credit: 3 or 4 hours.

For students who desire a working knowledge of complex variables; covers the standard topics and gives an introduction to integration by residues, the argument principle, conformal maps, and potential fields. Students desiring a systematic development of the foundations of the subject should take MATH 448. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 446 and MATH 448. Prerequisite: MATH 241 or MATH 380; or consent of instructor.

447 ***Real Variables*** credit: 3 or 4 hours.

Careful development of elementary real analysis including such topics as completeness property of the real number system; basic topological properties of  $n$ -dimensional space; convergence of numerical sequences and series of functions; properties of continuous functions; and basic theorems concerning differentiation and Riemann integration. 3 undergraduate hours. 3 or 4 graduate hours. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Credit is not given for both MATH 447 and MATH 444. Prerequisite: MATH 241 or equivalent; junior standing; MATH 347 or MATH 348, or equivalent experience; or consent of instructor.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

448 **Complex Variables** credit: 3 or 4 hours.

For students who desire a rigorous introduction to the theory of functions of a complex variable; topics include Cauchy's theorem, the residue theorem, the maximum modulus theorem, Laurent series, the fundamental theorem of algebra, and the argument principle. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 448 and MATH 446. Prerequisite: MATH 241 or MATH 380; MATH 447.

450 **Numerical Analysis** credit: 3 or 4 hours.

Same as CS 450, CSE 401 and ECE 491. See CS 450.

453 **Elementary Theory of Numbers** credit: 3 or 4 hours.

Basic introduction to the theory of numbers. Core topics include divisibility, primes and factorization, congruences, arithmetic functions, quadratic residues and quadratic reciprocity, primitive roots and orders. Additional topics covered at the discretion of the instructor include sums of squares, Diophantine equations, continued fractions, Farey fractions, recurrences, and applications to primality testing and cryptopgraphy. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or equivalent.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

458 **Numerical Linear Algebra** credit: 3 or 4 hours.

Same as CS 458 and CSE 412. See CS 458.

461 **Probability Theory** credit: 3 or 4 hours.

Introduction to mathematical probability; includes the calculus of probability, combinatorial analysis, random variables, expectation, distribution functions, moment-generating functions, and central limit theorem. Same as STAT 451. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Credit is not given for both MATH 461 and either MATH 408 or ECE 313. Prerequisite: MATH 241 or equivalent.

463 **Statistics and Probability I** credit: 4 hours.

Same as STAT 400. See STAT 400.

464 **Statistics and Probability II** credit: 3 or 4 hours.

Same as STAT 410. See STAT 410.

465 **Analysis of Variance** credit: 3 or 4 hours.

Same as STAT 424. See STAT 424.

468 **Topics in Applied Statistics** credit: 3 or 4 hours.

Same as STAT 430. See STAT 430.

469 **Methods of Applied Statistics** credit: 3 or 4 hours.

Same as STAT 420. See STAT 420.

471 **Actuarial Theory I** credit: 4 hours.

Distribution of the time-to-death random variable for a single life, and its implications for evaluations of insurance and annuity functions, net premiums, and reserves. Prerequisite: MATH 408 and MATH 210.

472 **Actuarial Theory II** credit: 3 or 4 hours.

Continuation of MATH 471. Emphasis is on multiple-life functions. 3 undergraduate hours. 3 or 4 graduate hours. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: MATH 471.

473 **Algorithms** credit: 0 to 4 hours.

Same as CS 473 and CSE 414. See CS 473.

475 **Formal Models of Computation** credit: 3 or 4 hours.

Same as CS 475. See CS 475.

476 **Actuarial Risk Theory** credit: 3 or 4 hours.

Mathematical analysis of the risk to an insurer due to variations in expected claim numbers and amounts; optimal insurance systems; the probability of ruin in the long run; reinsurance; dividend formulas. 3 undergraduate hours. 3 or 4 graduate hours. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: Credit or concurrent registration in STAT 409 or STAT 410.

477 **Survival Analysis** credit: 3 hours.

The statistical process of analyzing survival data, particularly for insurance applications. Parametric, semiparametric and nonparametric methods; special attention to censoring and truncation. Testing adequacy of selected models. Prerequisite: MATH 409 or MATH 464; MATH 471 is recommended but not required.

478 **Actuarial Modeling** credit: 3 or 4 hours.

Considers the specification and evaluation of various types of actuarial models. Examines severity, frequency, and compound distributions useful in modeling the insurance loss process. Credibility theory is also discussed. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 408, MATH 461 or MATH 463; credit or concurrent registration in MATH 409 or MATH 464.

481 **Vector and Tensor Analysis** credit: 3 or 4 hours.

Vector spaces, transformation properties, covariant and contravariant tensors, and differential geometry of surfaces; applications to relativity theory. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or MATH 380, or equivalent; or consent of instructor.

482 **Linear Programming** credit: 3 or 4 hours.

Rigorous introduction to a wide range of topics in optimization, including a thorough treatment of basic ideas of linear programming, with additional topics drawn from numerical considerations, linear complementarity,

integer programming and networks, polyhedral methods. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 410, MATH 415, or MATH 416.

484 **Nonlinear Programming** credit: 3 or 4 hours.

Iterative and analytical solutions of constrained and unconstrained problems of optimization; gradient and conjugate gradient solution methods; Newton's method, Lagrange multipliers, duality and the Kuhn-Tucker theorem; and quadratic, convex, and geometric programming. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241; MATH 347 or MATH 348; or equivalent; MATH 415 or equivalent; or consent of instructor.

This course satisfies the General Education Criteria for a Quant Reasoning II course.

487 **Advanced Engineering Math** credit: 3 or 4 hours.

Complex linear algebra, inner product spaces, Fourier transforms and analysis of boundary value problems, Sturm-Liouville theory. Same as ECE 493. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: One of MATH 284, MATH 285, MATH 286, MATH 441.

488 **Math Methods In Engineering** credit: 3 or 4 hours.

Matrices, determinants, bounds and approximations to eigenvalues, introduction to linear operator theory and inner product spaces, orthogonal expansions, and Fourier transforms. 4 hours of credit requires approval of the instructor and department with completion of additional work of substance. Prerequisite: MATH 241 or MATH 380, or equivalent.

489 **Differential Equations II** credit: 3 or 4 hours.

Treats systems of linear differential equations (including the necessary matrix theory), and then concentrates on nonlinear systems, studying their dynamics by means of phase plane analysis and other methods. Provides applications of nonlinear systems to physics and biology. 4 hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: One of MATH 284, MATH 285, MATH 286, MATH 441.

490 **Advanced Topics in Mathematics** credit: 1 to 4 hours.

Deals with selected topics and applications of mathematics; see Class Schedule or department office for current topics. May be repeated with approval. Prerequisite: Consent of instructor.

491 **Logic Design** credit: 3 hours.

Same as CS 462 and ECE 462. See ECE 462.

493 **Statistical Computing** credit: 3 or 4 hours.

Same as STAT 428. See STAT 428.

494 **Time Series Analysis** credit: 3 or 4 hours.

Same as STAT 429. See STAT 429.

496 **Honors Seminar** credit: 3 hours.

Careful study of a selected area of mathematics, carried out either deductively from axioms or inductively through problems; subject matter varies with instructor. 3 undergraduate hours. No graduate credit. May be repeated to a maximum of 6 hours. Prerequisite: Consent of Mathematics Honors Committee.

499 **Introduction Graduate Research** credit: 1 hours.

Seminar is required of all first-year graduate students in Mathematics. It provides a general introduction to the courses and research work in all of the areas of mathematics that are represented at the University of Illinois at Urbana-Champaign. Approved for S/U grading only. May be repeated to a maximum of 2 hours. Prerequisite: Graduate standing or consent of instructor.

500 **Abstract Algebra I** credit: 4 hours.

Isomorphism theorems for groups, centers of  $p$ -groups, simplicity of  $A_n$ , Jordan-Holder Theorem; Commutative Rings and Fields, PIDs, UFDs, Gauss's Lemma, splitting fields, Hilbert Basis Theorem, Zariski topology; Modules over Commutative Rings, structure theorem for finitely generated modules over PIDs, with applications to abelian groups and canonical forms for matrices; Zorn's lemma and applications, existence and uniqueness of algebraic closures; Categories and Functors, universal mapping properties, natural transformations, limits and colimits. Prerequisite: MATH 417 and MATH 418.

501 **Abstract Algebra II** credit: 4 hours.

Solvable groups, finite  $p$ -groups, semidirect products, Sylow's theorem; Galois Theory, transcendental extensions, separable and normal extensions, finite Galois groups, Theorem of the Primitive Element, Fundamental Theorem of Galois Theory, symmetric Function Theorem, examples, cyclotomic, cyclic and radical extensions; Modules over Arbitrary Rings, exact sequences, projective and injective modules, Tensor products, Matrix rings, Schur's lemma, Wedderburn's theorem on semisimple rings, group algebras, Maschke's theorem; Algebraic Geometry, varieties, morphisms of varieties, Noetherian properties, Irreducible varieties and prime ideals. Prerequisite: MATH 500.

502 **Commutative Algebra** credit: 4 hours.

Commutative rings and modules, prime ideals, localization, noetherian rings, primary decomposition, integral extensions and Noether normalization, the Nullstellensatz, dimension, flatness, Hensel's lemma, graded rings, Hilbert polynomial, valuations, regular rings, singularities, unique factorization, homological dimension, depth, completion. Possible further topics: smooth and etale extensions, ramification, Cohen-Macaulay modules, complete intersections. Prerequisite: MATH 501 or consent of instructor.

503 **Group Theory** credit: 4 hours.

Structure of groups, derived groups, nilpotence and solvability, and extensions and products. Prerequisite: MATH 501 or equivalent.

504 **Non-commutative Rings** credit: 4 hours.

Structure of Artinian rings, Morita theory, radicals, Brauer groups, finiteness conditions, and other topics at the choice of the instructor. Prerequisite: MATH 501 or consent of instructor.

505 **Homological Algebra** credit: 4 hours.

Definition and properties of the functors Ext and Tor; projective, injective, and flat modules; group extensions; dimensions of rings, and Hilbert theorem on syzygies. Prerequisite: MATH 501 or equivalent.

506 **Group Representation Theory** credit: 4 hours.

Representation of groups by linear transformations, group algebras, character theory, and modular representations. Prerequisite: MATH 501 or equivalent.

510 **Riemann Surf & Algebraic Curv** credit: 4 hours.

An introduction to Riemann Surfaces from both the algebraic and function-theoretic points of view. Topics include projective algebraic curves, differential forms, integration, divisors of poles and zeroes, linear systems, the Riemann-Roch theorem, Serre duality, and applications. Prerequisite: MATH 500 and MATH 542.

511 **Algebraic Geometry** credit: 4 hours.

Properties of affine and projective varieties defined over algebraically closed fields; rational mappings, birational geometry and divisors, especially on curves and surfaces; introduction to the language of schemes; and Riemann-Roch theorem for curves. Prerequisite: MATH 501.

518 **Differentiable Manifolds I** credit: 4 hours.

Definitions and properties of differentiable manifolds and maps, (co)tangent bundles, vector fields and flows, Frobenius theorem, differential forms, exterior derivatives, integration and Stokes' theorem, DeRham cohomology, inverse function theorem, Sard's theorem, transversality and intersection theory. Prerequisite: MATH 423 or MATH 481, or consent of instructor.

519 **Differentiable Manifolds II** credit: 4 hours.

Vector bundles, principal bundles, connections, parallel transport, curvature, Chern-Weyl theory, Hodge-DeRham theory. Other topics may include Riemannian geometry, symplectic geometry, spin geometry, and harmonic maps. Prerequisite: MATH 518 or consent of instructor.

521 **Riemannian Geometry** credit: 4 hours.

Local and global properties of Riemannian manifolds. Prerequisite: MATH 520.

522 **Lie Groups and Lie Algebras I** credit: 4 hours.

A general introduction to Lie groups and algebras and their representation theory. Theory of finite group representations, Lie groups as matrix groups, and as differentiable manifolds, Lie algebras as tangent spaces and as abstract objects, and their representations. Examples of the classical groups. May be repeated up to 8 hours. Prerequisite: Undergraduate linear algebra, abstract algebra, point set topology, differentiation on manifolds.

523 **Lie Groups and Lie Algebras II** credit: 4 hours.

The classification of simple Lie algebras, classification of highest weight representations, Weyl group actions, Lie group representations, homogeneous spaces, Clifford algebras, Spin groups and further applications. May be repeated to a maximum of 8 hours. Prerequisite: MATH 522.

524 **Linear Analysis on Manifolds** credit: 4 hours.

Study of topological invariants of differentiable and complex manifolds. Prerequisite: MATH 520 and MATH 526, or consent of instructor.

525 **Topology** credit: 4 hours.

Winding numbers, singular and de Rham homology and cohomology in dimension zero and one, fixed point theorems, Jordan curve theorem, covering spaces, fundamental groups, classification of surfaces, van Kampen Theorem, singular homology, Eilenberg-Steenrod axioms, homology groups of surfaces. Prerequisite: MATH 417 and MATH 448 or consent of instructor.

526 **Algebraic Topology** credit: 4 hours.

CW-complexes, relative homeomorphism theorem, cellular homology, cohomology, Kunneth theorem, Eilenberg-Zilber theorem, cup products, Poincare duality, examples. Prerequisite: MATH 525, MATH 500; or consent of instructor. MATH 501 is recommended but not required.

527 **Homotopy Theory** credit: 4 hours.

Homotopy groups, fibrations and cofibrations, Hurewicz theorem, obstruction theory, Whitehead theorem and additional topics perhaps drawn from Postnikov towers, Freudenthal suspension theorem, Blakers-Massey theorem, spectra. Prerequisite: MATH 526. MATH 501 is recommended but not required.

530 **Algebraic Number Theory** credit: 4 hours.

Further development of the theory of fields covering topics from valuation theory, ideal theory, units in algebraic number fields, ramification, function fields, and local class field theory. Prerequisite: MATH 500 or equivalent.

531 **Analytic Theory of Numbers I** credit: 4 hours.

Problems in number theory treated by methods of analysis; arithmetic functions, Dirichlet series, Riemann zeta function, L-functions, Dirichlet's theorem on primes in progressions, the prime number theorem. Prerequisite: MATH 448 and either MATH 417 or MATH 453.

532 **Analytic Theory of Numbers II** credit: 4 hours.

Development of themes from MATH 531 and further topics chosen from additive number theory, asymptotic properties of multiplicative functions, circle method, diophantine approximation, lattice point problems, metric theory, modular forms, sieve theory. May be repeated. Prerequisite: MATH 531.

533 **Fiber Spaces and Char Classes** credit: 4 hours.

Continuation of MATH 527. Study of fiber bundles and their associated characteristic classes; applications to geometric problems. Prerequisite: MATH 527.

535 **General Topology** credit: 4 hours.

Study of topological spaces and maps, including Cartesian products, identifications, connectedness, compactness, uniform spaces, and function spaces. Prerequisite: Consent of instructor.

540 **Real Analysis I** credit: 4 hours.

Lebesgue measure on the real line; integration and differentiation of real valued functions of a real variable; and additional topics at discretion of instructor. Prerequisite: MATH 447 or equivalent.

541 **Real Analysis II** credit: 4 hours.

Abstract measure theory; integration on general measure spaces; and introduction to functional analysis.  
Prerequisite: MATH 540.

542 **Complex Variables I** credit: 4 hours.

Topics include the Cauchy theory, harmonic functions, entire and meromorphic functions, and the Riemann mapping theorem. Prerequisite: MATH 446 and MATH 447, or MATH 448.

543 **Complex Variables II** credit: 4 hours.

Continuation of MATH 542. Topics include subharmonic functions, Nevanlinna theory, analytic continuation and Riemann surfaces, and univalent functions. Prerequisite: MATH 542.

545 **Harmonic Analysis** credit: 4 hours.

Harmonic analysis on the circle, the line, and the integers, i.e., Fourier series and transforms; locally compact Abelian groups; convergence and summability; conjugate functions; Hardy spaces; uniqueness; Tauberian theorems; almost-periodic functions; commutative Banach algebras. Prerequisite: MATH 448 and MATH 541; knowledge of Banach spaces.

546 **Hilbert Spaces** credit: 4 hours.

Geometrical properties of Hilbert spaces; linear operators; and the spectral theory for self adjoint and related operators. Prerequisite: MATH 541.

550 **Ordinary Diff Equations** credit: 4 hours.

Existence, uniqueness, and continuation of solutions; topics selected from the following: the theory of linear differential operators, Sturm-Liouville theory, stability theory, and qualitative theory of differential equations. Prerequisite: MATH 447; a first course in ordinary differential equations.

551 **Dynamical Systems Theory** credit: 4 hours.

Course is an introduction to the study of dynamical systems. Students who intend to do research in nonlinear dynamics are encouraged to take this course. Specific topics will be chosen to illustrate the theory and use of techniques from global analysis and nonlinear dynamics such as (1) discrete dynamical systems, (2) global theory of ordinary differential equations, (3) Hamiltonian systems, (4) KAM theory, (5) bifurcation and stability, (6) Hopf index theory of vector fields, (7) Morse theory of gradient vector fields, (8) Lyapunov theory, (9) infinite dimensional dynamical systems, (10) structural stability. Prerequisite: Consent of instructor.

552 **Numerical Methods for PDEs** credit: 4 hours.

Same as CS 555 and CSE 510. See CS 555.

553 **Partial Differential Equations** credit: 4 hours.

Basic introduction to the study of partial differential equations; topics include: the Cauchy problem, power-series methods, characteristics, classification, canonical forms, well-posed problems, Riemann's method for hyperbolic equations, the Goursat problem, the wave equation, Sturm-Liouville problems and separation of variables, Fourier

series, the heat equation, integral transforms, Laplace's equation, harmonic functions, potential theory, the Dirichlet and Neumann problems, and Green's functions. Prerequisite: Consent of instructor.

554 **Linear Anal & Part Diff Eq** credit: 4 hours.

Course will provide students with the basic background in linear analysis associated with partial differential equations. The specific topics chosen will be largely up to the instructor, but will cover such areas as linear partial differential operators, distribution theory and test functions, Fourier transforms, Sobolev spaces, pseudodifferential operators, microlocal analysis, and applications of the above topics. Prerequisite: MATH 447, MATH 489 or consent of instructor.

555 **Nonlinear Anal & Part Diff Eq** credit: 4 hours.

Course will provide students with the basic background in nonlinear analysis associated with partial differential equations. The specific topics chosen will be largely up to the instructor, but will cover such areas as existence and uniqueness techniques, nonexistence and finite time blow-up results, hyperbolic conservation laws, weak solutions, stability theory, nonlinear elliptic theory, regularity theory. Prerequisite: MATH 554 or consent of instructor.

556 **Methods of Math Physics I** credit: 4 hours.

Course covers several basic mathematical methods of wide use in physics and engineering. Topics will be selected from the following: calculus of variations, Sturm-Liouville theory and eigenvalue problems, Green's functions and generalized functions, Hilbert space techniques. Prerequisite: Advanced Calculus.

557 **Methods of Math Physics II** credit: 4 hours.

Course covers several basic mathematical methods of wide use in physics and engineering. Topics will be selected from the following: integral equations, spectral theory and Hilbert spaces, inverse spectral theory, soliton and waterwave theory, asymptotic methods. Prerequisite: MATH 556 or consent of instructor.

559 **Asymptotic Methods** credit: 4 hours.

Same as NPRE 559, PHYS 522, and TAM 549. See TAM 549.

561 **Theory of Probability I** credit: 4 hours.

Mathematical foundations of probability and stochastic processes; probability measures, random variables, distribution functions, convergence theory, the Central Limit Theorem, conditional expectation, and martingale theory. Same as STAT 551. Prerequisite: MATH 541 or consent of instructor.

562 **Theory of Probability II** credit: 4 hours.

Continuation of MATH 561. Same as STAT 552. Prerequisite: MATH 561.

564 **Applied Stochastic Processes** credit: 4 hours.

Introduction to topics such as spectral analysis, filtering theory, and prediction theory of stationary processes; Markov chains and Markov processes. Same as STAT 555. Prerequisite: MATH 446 and MATH 447.

567 **Topics in Actuarial Theory I** credit: 4 hours.

Selected topics in advanced actuarial science. May be repeated to a maximum of 16 hours. Prerequisite: Consent of instructor.

568 **Topics in Actuarial Theory II** credit: 4 hours.

Topics in mathematical theory of actuarial science beyond basic life contingencies, such as graduation of mortality tables, survival models, mathematics of demography. See Class Schedule or department office for current topics. A paper will generally be required. May be repeated to a maximum of 16 hours. Prerequisite: STAT 409 or STAT 410 or equivalent; credit or concurrent registration in MATH 471.

570 **Mathematical Logic** credit: 4 hours.

Development of first order predicate logic; completeness theorem; formalized number theory and the Godel incompleteness theorem. Prerequisite: MATH 417 or consent of instructor.

571 **Model Theory** credit: 4 hours.

Techniques for constructing models, including compactness and Lowenheim-Skolem theorems, unions of elementary chains, and omitting types construction; categorical theories; ultraproducts; saturated models; quantifier elimination; applications to algebraically closed fields, real closed fields, and other fundamental structures of mathematics. Prerequisite: MATH 570 or consent of instructor.

573 **Recursive Function Theory** credit: 4 hours.

Various characterizations of the class of recursive (i.e., computable) functions; the Church-Turing thesis; unsolvability of the halting problem; the recursion theorem and the enumeration theorem; relative computability, the jump operation, and the arithmetical hierarchy; recursively enumerable sets; degrees of unsolvability; and the priority method. Prerequisite: MATH 570 or consent of instructor.

574 **Set Theory** credit: 4 hours.

Zermelo-Fraenkel axiomatic set theory; basic concepts in set theory such as ordinal, cardinal, rank, and definition by transfinite recursion; Godel's constructible universe; introduction to forcing; Boolean valued universes; large cardinals; consistency and independence of the continuum hypothesis and the axiom of choice. Prerequisite: MATH 570 or consent of instructor.

578 **Computational Complexity** credit: 4 hours.

Same as CS 579 and ECE 579. See CS 579.

579 **Coding Theory** credit: 4 hours.

Same as CS 577 and ECE 556. See ECE 556.

580 **Combinatorial Mathematics** credit: 4 hours.

Fundamental results on core topics of combinatorial mathematics: classical enumeration, basic graph theory, extremal problems on finite sets, probabilistic methods, design theory, discrete optimization. Same as CS 571. Prerequisite: Consent of instructor.

581 **Extremal Graph Theory** credit: 4 hours.

Extremal problems and parameters for graphs. Distance and connectivity, matching and factors, vertex and edge colorings, perfect and imperfect graphs, intersection classes and intersection parameters, Turan's theorem, graph Ramsey theory, graph decomposition and other extremal problems. Same as CS 572. Prerequisite: MATH 580 or consent of instructor.

582 **Structure of Graphs** credit: 4 hours.

Structure of graphs and properties of special classes of graphs. Degree sequences and reconstruction, structure of  $k$ -connected graphs, Hamiltonian cycles and circumference, planar graphs and their properties, graph minors, cycle coverings, matroidal and algebraic aspects of graphs. Prerequisite: MATH 580 or consent of instructor.

583 **Partial Orders and Comb Optim** credit: 4 hours.

Combinatorial aspects of partially ordered sets and their relation to optimization problems. Structure of posets and lattices, Dilworth's theorem and generalizations, linear extensions and sorting, dimension of posets, order ideals, extremal set theory, integer programming and minmax relations, matroids and their applications. Prerequisite: MATH 580 or consent of instructor.

584 **Methods of Combinatorics** credit: 4 hours.

Combinatorial methods and other mathematical methods for combinatorial problems. Enumeration by bijections and generating functions, probabilistic methods for existence proofs and asymptotic analysis, randomized algorithms, Ramsey's theorem and related topics, combinatorial designs and their applications, geometric problems and methods. Same as CS 575. Prerequisite: MATH 580 or consent of instructor.

587 **Optimiz by Vector Space Methods** credit: 4 hours.

Same as ECE 580. See ECE 580.

588 **Optimization in Networks** credit: 4 hours.

Theory and methods for optimization over directed graphs; paths, cuts, flows, and potentials; matchings; PERT and CPM; max flow, min path, out-of-kilter, Hungarian, and other algorithms; nonlinear cost functionals; painting theory; and existence and duality. Prerequisite: MATH 241.

589 **Conjugate Duality and Optim** credit: 4 hours.

Convex analysis for constrained extremum problems; convex sets, cones, and functions; separation; Fenchel transform; duality correspondences; differential theory; nonlinear programming; sensitivity; and perturbational duality for primal, dual, and Lagrangian problems. Prerequisite: MATH 415 and MATH 447, or consent of instructor.

595 **Advanced Topics in Math** credit: 1 to 4 hours.

May be repeated in the same or separate semesters. Prerequisite: Consent of instructor.

597 **Reading Course** credit: 1 to 8 hours.

Approved for both letter and S/U grading. May be repeated in the same or separate terms to a maximum of 8 hours. Prerequisite: Consent of instructor.

598 **Literature Seminar in Math** credit: 0 to 4 hours.

Seminar on topics of current interest in mathematics. Students present seminars and discussions on various topics. See Class Schedule for current topics. Recommended for all Mathematics students. Approved for both letter and S/U grading. Prerequisite: Consent of instructor.

599 **Thesis Research** credit: 0 to 16 hours.

May be repeated. Approved for S/U grading only. Prerequisite: Consent of instructor.