

Course Catalog - Fall 2004

Mathematics

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

(MATH 102) Methods of elementary algebra, including simplification of algebraic expressions, solving linear quadratic equations, equations of lines, systems of linear equations, and radicals. Enrollment is restricted.

Prerequisite: Score on appropriate placement test, or consent of Mathematics Department. Credit may not be used toward graduation in the College of LAS.

012 **Algebra** Credit: 3 hours.

(MATH 112) 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. Prerequisite: 1.5 units of high school algebra, and 1 unit of high school geometry. Credit is not given for both MATH 012 and 016. Credit not applicable toward graduation in certain curricula.

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

(MATH 116) Prerequisite: 1.5 units of high school algebra; 1 unit of high school geometry. Credit is not given for both MATH 016 and 012. Credit not applicable toward graduation in certain curricula.

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

(MATH 203) 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 aQuant Reasoning I course.

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

(MATH 117) 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 aQuant Reasoning I course.

118 **Numeracy** Credit: 3 hours.

(MATH 118) Elementary course for students whose major interests are not in engineering or the physical sciences; emphasizes understanding of mathematical aspects of modern, real-world problems; includes concepts from combinatorics, exponential growth, probability and statistics; problem-solving strategies. Prerequisite: Two units of high school algebra, and one unit of high school geometry.

This course satisfies the General Education Criteria for aQuant Reasoning I course.

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

(MATH 119) 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 aQuant Reasoning I course.

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

(MATH 124) 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 ACT score.

This course satisfies the General Education Criteria for aQuant Reasoning I course.

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

(MATH 125) 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 225. Prerequisite: MATH 012, or an adequate ACT score.

161 **Statistics** Credit: 3 hours.

(MATH 161) Same as STAT 100. See STAT 100.

This course satisfies the General Education Criteria for aQuant Reasoning I course.

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

(MATH 198) 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.

(MATH 199) May be repeated.

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

(MATH 210) Study of compound interest and annuities; applications to problems in finance. Prerequisite: MATH 230 or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning I course.

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

(MATH 213) 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. Prerequisite: MATH 220 or equivalent. Students may not receive credit for both MATH 213 and CS 173.

This course satisfies the General Education Criteria for aQuant Reasoning I course.

220 **Calculus I** Credit: 5 hours.

(MATH 120) 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 circular functions. Credit is not given for both MATH 220 and 234. Prerequisite: MATH 016 or equivalent; or an adequate ACT score.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

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

(MATH 225) 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 either MATH 125 or MATH 415.

Prerequisite: MATH 220 or equivalent.

230 **Calculus II** Credit: 3 hours.

(MATH 130) Second course in calculus and analytic geometry: techniques of integration, conic sections, polar coordinates, and infinite series. Prerequisite: MATH 220.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

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

(MATH 134) Introduction to the concept of functions and the basic ideas of the calculus. Credit is not given for MATH 234 and MATH 220. Prerequisite: MATH 012.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

242 **Calculus of Several Variables** Credit: 3 hours.

(MATH 242) Third course in calculus and analytic geometry: three dimensional space, functions of several variables, partial derivatives, and multiple integrals. Credit is not given for both MATH 242 and either MATH 243 or 244. Prerequisite: MATH 230.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

243 **Calculus III Plus** Credit: 4 hours.

(MATH 243) 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 MATH 243 and either MATH 242 or 244. Prerequisite: MATH 230.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

244 **Calculus for Business II** Credit: 5 hours.

(MATH 244) Continuation of MATH 234. Calculus of the trigonometric functions, Taylor polynomials, and infinite series; analytic geometry in n dimensions, vector calculus, classical extremum problems in n variables, and

Lagrange multipliers; and multiple integrals. Credit is not given for both MATH 244 and either MATH 242 or 243. Prerequisite: MATH 234 or consent of instructor.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

245 Accelerated Calculus II Credit: 5 hours.

(MATH 245) Continuation of MATH 235. Polar coordinates, vectors and parametric equations, infinite series, functions of several variables, partial derivatives, and multiple integrals. Credit is not given for both MATH 245 and either MATH 242, 243, or 344. Prerequisite: MATH 235.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

249 Honors Course in Mathematics Credit: 1 hours.

(MATH 149) Prerequisite: Concurrent registration in an honors section of MATH 220, 230, or 242; consent of departments. Enrollment is strictly limited to students with superior mathematical talents.

257 Numerical Methods Credit: 3 hours.

(MATH 257) Same as CS 257. See CS 257.

290 Symbolic Computation Lab Credit: 1 hours.

(MATH 190) 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.

347 Fundamental Mathematics Credit: 3 hours.

(MATH 247) 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. Prerequisite: MATH 230.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

348 Fundamental Mathematics-ACP Credit: 4 hours.

(MATH 248) Course is identical to MATH 347 except for the additional writing component. Credit is not given for both MATH 348 and 347. Prerequisite: MATH 230 and completion of the campus COMPOSITION I general education requirement.

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

367 Math Issues National Security Credit: 3 hours.

(MATH 267) Applications of mathematics to aspects of physical, biological, and social sciences that affect national security. Same as GBLB 367. Prerequisite: Completion of the Quantitative Reasoning I requirement, or consent of instructor.

370 Actuarial Problem Solving Credit: 1 to 2 hours.

(MATH 270) Methods and techniques of solving problems in actuarial mathematics for advanced students intending to enter the actuarial profession. May be repeated to a maximum of 4 hours. Prerequisite: Consent of instructor.

380 Advanced Calculus Credit: 3 hours.

(MATH 280) 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. Prerequisite: MATH 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

383 Intro to Linear Programming Credit: 3 hours.

(MATH 283) Systems of linear inequalities, the standard canonical and general linear problems, and the simplex methods of solution. Prerequisite: MATH 125 or 225.

385 Intro Differential Equations Credit: 3 hours.

(MATH 285) Intended for engineering students and others who require a working knowledge of differential equations; included are techniques and applications of ordinary differential equations and an introduction to partial differential equations. Credit is not given for both MATH 385 and either MATH 386 or 441. Prerequisite: MATH 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

386 Intro to Differential Eq Plus Credit: 4 hours.

(MATH 286) Intended for engineering students and others who require a working knowledge of differential equations, included are techniques and applications of ordinary differential equations, linear systems of differential equations, and an introduction to partial differential equations. Credit not given for MATH 386 and either MATH 385 or 441 Prerequisite: MATH 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

390 Individual Study Credit: 0 to 3 hours.

(MATH 290) Guided individual study of advanced topics not covered in other courses. May be repeated to a maximum of 8 hours. Prerequisite: Consent of instructor.

395 Mathematics Honors Sequence Credit: 1 to 5 hours.

(MATH 295) Honors sequence in Mathematics. Prerequisite: BC advanced placement score of 5 and consent of instructor.

402 Non Euclidean Geometry Credit: 3 or 4 hours.

(MATH 302) 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. 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 242 or 243; MATH 347 or 348 or equivalent experience; or consent of instructor.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

403 Euclidean Geometry Credit: 3 or 4 hours.

(MATH 303) 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. 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 242 or 243, or consent of instructor

This course satisfies the General Education Criteria for aQuant Reasoning II course.

405 Teacher's Course Credit: 3 or 4 hours.

(MATH 305) Presents selected topics in mathematics that are related to the content of secondary school mathematics programs; provides background for enrichment topics for secondary school students. Subject matter varies with the instructor. 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 242 or 243; MATH 347 or 348 or equivalent experience; or consent of instructor.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

406 History of Calculus Credit: 3 or 4 hours.

(MATH 306) Examination of the historical origins and genesis of the concepts of the calculus; includes mathematical developments from the ancient Greeks to the eighteenth century. 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 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

408 Actuarial Statistics I Credit: 4 hours.

(MATH 308) Same as STAT 408. See STAT 408.

409 Actuarial Statistics II Credit: 4 hours.

(MATH 309) Same as STAT 409. See STAT 409.

412 Graph Theory Credit: 3 or 4 hours.

(MATH 312) 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. 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 348 or equivalent experience or CS 273.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

413 Intro to Combinatorics Credit: 3 or 4 hours.

(MATH 313) 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 348 or equivalent experience.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

414 Mathematical Logic Credit: 3 or 4 hours.

(MATH 314) 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. 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 348 or equivalent experience.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

415 Linear Algebra Credit: 3 or 4 hours.

(MATH 315) Introductory course emphasizing techniques of linear algebra; topics include matrix operations, determinants, linear equations, vector spaces, linear transformations, eigenvalues, and eigenvectors. 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 not given for both MATH 225 and either MATH 125 or MATH 415. Prerequisite: MATH 242 or 243.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

417 Intro to Abstract Algebra Credit: 3 or 4 hours.

(MATH 317) Fundamental theorem of arithmetic. Congruencies, groups and group actions, Polya counting, rings, fields, and roots of polynomials. Emphasizes proofs. 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 415 and either MATH 347 or 348; or consent of instructor.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

418 Advanced Linear Algebra Credit: 3 or 4 hours.

(MATH 318) Vector spaces, ruler and compass constructions, finite fields, with application to Steiner systems. Linear codes or Groeber bases. Emphasizes proofs. 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 417 or consent of instructor

421 Symbolic Algebra Credit: 4 hours.

(MATH 321) Introduction to algorithmic, computational algebra. The basic object of study is families of polynomials in several variables with coefficients from a chosen field. The theory and algorithms have applications ranging from highly theoretical results in algebraic geometry to practical questions in applied fields like robotics. Prerequisite: MATH 417 or consent of instructor.

423 Differential Geometry Credit: 3 or 4 hours.

(MATH 323) 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. 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 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

432 Set Theory and Topology Credit: 3 or 4 hours.

(MATH 332) Informal set theory, cardinal and ordinal numbers, and the axiom of choice; topology of metric spaces and introduction to general topological spaces 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 348 or consent of instructor.

439 Philosophy of Mathematics Credit: 3 or 4 hours.

(MATH 339) Same as PHIL 439. See PHIL 439.

441 Differential Equations Credit: 3 or 4 hours.

(MATH 341) 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 385. 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 441 and MATH 385. Prerequisite: MATH 242 or 243, or equivalent; MATH 347 or 348 recommended.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

442 Intro Partial Diff Equations Credit: 3 or 4 hours.

(MATH 342) Introduces students to partial differential equations, emphasizing the wave, diffusion and potential (Laplace) equations. The focus is on understanding the physical meaning and mathematical properties of solutions of partial differential equations. Methods include fundamental solutions and transform methods for problems on the line, and separation of variables using orthogonal series for problems in regions with boundary. Convergence of Fourier series is covered in detail. 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 385 or 441.

444 Elementary Real Analysis Credit: 3 or 4 hours.

(MATH 344) 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. 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 444 and 447. Prerequisite: MATH 242 or 243; MATH 347 or 348 or equivalent experience.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

446 Applied Complex Variables Credit: 3 or 4 hours.

(MATH 346) 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. 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 446 and 448. Prerequisite: MATH 243 or 380 or consent of instructor.

447 Real Variables Credit: 3 or 4 hours.

(MATH 347) 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 444. Prerequisite: MATH 242 or 243 or equivalent, and junior standing; MATH 347 or 348 or equivalent experience; or consent of instructor.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

448 Complex Variables Credit: 3 or 4 hours.

(MATH 348) 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. 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 448 and 446. Prerequisite: MATH 243 or 380; MATH 447.

450 Intro to Numerical Analysis Credit: 3 or 4 hours.

(MATH 350) Same as CS 450, CSE 401, and ECE 491. See CS 450.

453 Elementary Theory of Numbers Credit: 3 or 4 hours.

(MATH 353) Topics covered include divisibility, primes, congruences, quadratic reciprocity, and Farey sequences. 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 242 or 243, or equivalent.

This course satisfies the General Education Criteria for aQuant Reasoning II course.

455 Numerical Methods for PDEs Credit: 3 or 4 hours.

(MATH 355) Same as CS 455, and CSE 411. See CS 455.

458 Numerical Linear Algebra Credit: 3 or 4 hours.

(MATH 358) Same as CS 458, and CSE 412. See CS 458.

459 Numerical Approx and ODEs Credit: 3 or 4 hours.

(MATH 359) Same as CS 459, and CSE 413. See CS 459.

461 Probability Theory I Credit: 3 or 4 hours.

(MATH 361) Introduction to mathematical probability; includes the calculus of probability, combinatorial analysis, random variables, expectation, distribution functions, moment-generating functions, and central limit theorem. Prepares students for MATH 466. Same as STAT 451. 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 242 or 243, or equivalent.

463 Statistics and Probability I Credit: 4 hours.

(MATH 363) Same as STAT 400. See STAT 400.

464 Statistics and Probability II Credit: 3 or 4 hours.

(MATH 364) Same as STAT 410. See STAT 410.

465 Analysis of Variance Credit: 3 or 4 hours.

(MATH 365) Same as STAT 424. See STAT 424.

466 Probability Theory II Credit: 3 or 4 hours.

(MATH 366) Continuation of MATH 461. Includes random walks, discrete and continuous time Markov chains, and special topics selected from weak stationarity, the multivariate central limit theorem, probability model building, stochastic equations, martingale theory, and renewal theory. Same as STAT 456. 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 461 or STAT 410.

468 Topics in Applied Statistics Credit: 3 or 4 hours.

(MATH 368) Same as STAT 430. See STAT 430.

469 Methods of Applied Statistics Credit: 3 or 4 hours.

(MATH 369) Same as STAT 420. See STAT 420.

470 Actuarial Numerical Analysis Credit: 3 hours.

(MATH 370) Numerical methods needed in actuarial science including iterative methods of solving equations, interpolation, numerical integration and linear systems. In addition, the theory of finite differences, and applications to actuarial problems will be covered. The level will be consistent with professional examinations in the field. Credit is not given for both MATH 470 and CS/MATH 257. Prerequisite: MATH 242 or 243, MATH 210, and a 100-level computer science course, or consent of instructor

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

471 Actuarial Theory I Credit: 4 hours.

(MATH 371) 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 210.

472 Actuarial Theory II Credit: 3 or 4 hours.

(MATH 372) 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: 3 or 4 hours.

(MATH 373) Same as CS 473, and CSE 414. See CS 473.

475 Formal Models of Computation Credit: 3 or 4 hours.

(MATH 375) Same as CS 475. See CS 475.

476 Actuarial Risk Theory Credit: 3 or 4 hours.

(MATH 376) 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 410.

477 Survival Analysis Credit: 3 hours.

(MATH 377) 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 464; MATH 471 is recommended but not required.

478 Actuarial Modeling Credit: 3 or 4 hours.

(MATH 378) 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, 461 or 463; credit or concurrent registration in MATH 409 or 464.

481 Vector and Tensor Analysis Credit: 3 or 4 hours.

(MATH 381) Vector spaces, transformation properties, covariant and contravariant tensors, and differential geometry of surfaces; applications to relativity theory. 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 243 or 380 or equivalent; or consent of instructor.

482 Linear Programming Credit: 3 or 4 hours.

(MATH 382) 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. 3 undergraduate hours. 3 or 4 graduate hours. Four hours of credit requires approval of the instructor and completion of additional work of substance. Prerequisite: MATH 415.

484 Nonlinear Programming Credit: 3 or 4 hours.

(MATH 384) 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. 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 242 or 243; MATH 347 or 348 or equivalent experience; and a knowledge of linear algebra equivalent to MATH 415; or consent of instructor.

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

489 Differential Equations II Credit: 3 or 4 hours.

(MATH 385) Continuation of MATH 385. The course treats systems of linear differential equations (and includes the necessary matrix theory), and then concentrates on nonlinear systems, studying their dynamics by means of phase plane analysis and other methods. Applications of nonlinear systems to physics and biology will be given. 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 385 or 441.

490 Topics in Mathematics Credit: 1 to 4 hours.

(MATH 351) Deals with topics in the application of mathematics to the physical, biological, and social sciences; see Timetable or department office for current topics. May be repeated with approval. Prerequisite: Consent of instructor.

491 Logic Design Credit: 3 hours.

(MATH 391) Same as CS 462, and ECE 462. See ECE 462.

493 Statistical Computing Credit: 3 or 4 hours.

(MATH 393) Same as STAT 428. See STAT 428.

494 Time Series Analysis Credit: 3 or 4 hours.

(MATH 394) Same as STAT 429. See STAT 429.

496 Honors Seminar Credit: 3 hours.

(MATH 296) 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.

498 Math Methods in Engineering Credit: 3 or 4 hours.

(MATH 388) Matrices, determinants, bounds and approximations to eigenvalues, introduction to linear operator theory and inner product spaces, orthogonal expansions, and Fourier transforms. 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 380 or equivalent.

499 Introduction Graduate Research Credit: 1 hours.

(MATH 400) 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. May be repeated to a maximum of 2 hours. Prerequisite: Graduate standing or consent of instructor.

500 Abstract Algebra I Credit: 4 hours.

501 Abstract Algebra II Credit: 4 hours.

(MATH 402) 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.

(MATH 403) 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 étale extensions, ramification, Cohen-Macaulay modules, complete intersections. Prerequisite: MATH 501 or consent of instructor.

503 Group Theory Credit: 4 hours.

(MATH 404) Structure of groups, derived groups, nilpotence and solvability, and extensions and products. Prerequisite: MATH 501 or equivalent.

504 Non-commutative Rings Credit: 4 hours.

(MATH 409) 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.

(MATH 406) 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.

(MATH 407) Representation of groups by linear transformations, group algebras, character theory, and modular representations. Prerequisite: MATH 501 or equivalent.

507 Lie Algebras Credit: 4 hours.

(MATH 408) Examples of Lie algebras (low dimensions, Lie algebras of Lie groups, free algebras, and universal enveloping algebra); Poincare-Birkoff-Witt theorem; nilpotent and solvable algebras; Cartan subalgebras; structure of semisimple algebras; real forms; and representations. Prerequisite: MATH 500; credit or concurrent registration in MATH 501.

508 Computer Algebra Systems Credit: 4 hours.

(MATH 420) Hands-on exploration of specialized computer algebra systems, their capabilities and applications. Each student will be required to complete an individual project containing original work. Prerequisite: MATH 417 or an equivalent course in abstract algebra.

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 542.

511 Algebraic Geometry Credit: 4 hours.

(MATH 422) 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.

520 Differentiable Manifolds Credit: 4 hours.

(MATH 423) Definition and properties of differentiable manifolds and maps, introducing vector fields, tangent bundles, differential forms, exterior derivatives, and foliations. Prerequisite: MATH 423 or 481, or consent of instructor.

521 Riemannian Geometry Credit: 4 hours.

(MATH 424) Local and global properties of Riemannian manifolds. Prerequisite: MATH 520.

522 Lie Groups Credit: 4 hours.

(MATH 427) Study of groups which are also differentiable manifolds. Prerequisite: MATH 520.

524 Linear Analysis on Manifolds Credit: 4 hours.

(MATH 425) Study of topological invariants of differentiable and complex manifolds. Prerequisite: MATH 520 and 526, or consent of instructor.

525 Topology Credit: 4 hours.

(MATH 430) Winding numbers, singular and de Rahm 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 448 or consent of instructor.

526 Algebraic Topology Credit: 4 hours.

(MATH 431) CW-complexes, relative homeomorphism theorem, cellular homology, cohomology, Kunneth theorem, Eilenberg-Zilber theorem, cup products, Poincar duality, examples. MATH 501 is recommended but not required. Prerequisite: MATH 525, 500; or consent of instructor.

527 Homotopy Theory Credit: 4 hours.

(MATH 432) 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.

(MATH 405) 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 501 or equivalent.

531 Analytic Theory of Numbers I Credit: 4 hours.

(MATH 453) 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 417 or 453.

532 Analytic Theory of Numbers II Credit: 4 hours.

(MATH 454) 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.

(MATH 433) Continuation of MATH 527. Study of fiber bundles and their associated characteristic classes; applications to geometric problems. Prerequisite: MATH 527.

534 Geometric Topology Credit: 4 hours.

(MATH 434) Topics from geometric topology: complexes, cutting and pasting, and other constructions with applications to areas such as manifolds and knots. Prerequisite: MATH 525.

535 General Topology Credit: 4 hours.

(MATH 435) 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.

(MATH 441) 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.

(MATH 442) Abstract measure theory; integration on general measure spaces; and introduction to functional analysis. Prerequisite: MATH 540.

542 Complex Variables I Credit: 4 hours.

(MATH 440) Topics include the Cauchy theory, harmonic functions, entire and meromorphic functions, and the Riemann mapping theorem. Prerequisite: MATH 446 and 447, or MATH 448.

543 Complex Variables II Credit: 4 hours.

(MATH 445) 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.

(MATH 448) 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 541; knowledge of Banach spaces.

546 Hilbert Spaces Credit: 4 hours.

(MATH 446) 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.

551 Dynamical Systems Theory Credit: 4 hours.

(MATH 467) 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.

553 Partial Differential Equations Credit: 4 hours.

(MATH 444) 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.

(MATH 495) 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, 489 or consent of instructor.

555 Nonlinear Anal & Part Diff Eq Credit: 4 hours.

(MATH 496) 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.

(MATH 455) 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.

(MATH 456) 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.
(MATH 459) Same as NPRE 559, PHYS 522, and TAM 549. See TAM 549.
- 561 Theory of Probability I** Credit: 4 hours.
(MATH 451) 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.
(MATH 452) Continuation of MATH 561 Same as STAT 552. Prerequisite: MATH 561.
- 564 Applied Stochastic Processes** Credit: 4 hours.
(MATH 461) 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 447.
- 567 Topics in Actuarial Theory I** Credit: 4 hours.
(MATH 472) Selected topics in advanced actuarial science. May be repeated up to 1 time(s). Prerequisite: Consent of instructor.
- 568 Topics in Actuarial Theory II** Credit: 4 hours.
(MATH 477) Topics in mathematical theory of actuarial science beyond basic life contingencies, such as graduation of mortality tables, survival models, mathematics of demography. See Timetable or department office for current topics. A paper will generally be required. May be repeated to a maximum of 8 hours. Prerequisite: STAT 409 or 410 or equivalent; credit or concurrent registration in MATH 471.
- 570 Mathematical Logic** Credit: 4 hours.
(MATH 410) 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.
(MATH 411) 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.
(MATH 412) 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.
(MATH 413) 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.
(MATH 479) Same as CS 579, and ECE 579. See ECE 579.
- 579 Coding Theory** Credit: 4 hours.
(MATH 476) Same as CS 577, and ECE 556. See ECE 556.
- 580 Combinatorial Mathematics** Credit: 4 hours.
(MATH 470) 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.
(MATH 417) 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.
(MATH 418) 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.
(MATH 473) 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.

(MATH 474) 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 Optimization by Vector Methods Credit: 4 hours.

(MATH 480) Introduction to normed, Banach, and Hilbert spaces; applications of the projection theorem and the Hahn-Banach Theorem to problems of minimum norm, least squares estimation, mathematical programming, and optimal control; the Kuhn-Tucker Theorem and Pontryagin's maximum principle; and introduction to iterative methods. Same as ECE 580. Prerequisite: MATH 415 or 482, and MATH 447 or consent of instructor.

588 Optimization in Networks Credit: 4 hours.

(MATH 483) 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 242 or 243.

589 Conjugate Duality and Optim Credit: 4 hours.

(MATH 484) 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 447, or consent of instructor.

595 Advanced Topics in Math Credit: 4 hours.

(MATH 468) Prerequisite: Consent of instructor.

597 Reading Course Credit: 1 to 8 hours.

(MATH 490) 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.

(MATH 491) Seminar on topics of current interest in mathematics. Students present seminars and discussions on various topics. See Timetable for current topics. Recommended for all Mathematics students. Prerequisite: Consent of instructor.

599 Thesis Research Credit: 0 to 16 hours.

(MATH 499) May be repeated. Approved for S/U grading only. Prerequisite: Consent of instructor.