

2011-13 Cal Poly Catalog

Mathematics Department

MATH–MATHEMATICS

Satisfactory completion of the Entry Level Mathematics (ELM) requirement is a prerequisite for enrollment in all mathematics courses except MATH 100 and MATH 104. For additional mathematics placement (MAPE) information, see page 31.

MATH 100 Beginning Algebra Review (3) (CR/NC)

Review of basic algebra skills at the beginning algebra level intended primarily to prepare students for MATH 104. Course open only to students who have taken the ELM examination and are not qualified for MATH 104. Not for baccalaureate credit. Credit/No Credit grading only. 3 lectures.

MATH 104 Intermediate Algebra (3) (CR/NC)

Review of basic algebra skills at the intermediate algebra level intended primarily to prepare students for MATH 116. Not for baccalaureate credit. Credit/No Credit grading only. 3 lectures. Prerequisite: Appropriate score on the ELM examination, or credit in MATH 100.

MATH 110 Beginning Algebra Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of beginning algebra. Not for baccalaureate credit. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 100.

MATH 112 The Nature of Modern Mathematics (4) GE B1

Topics from contemporary mathematics, their development, applications, and role in society. Some typical topics, to be chosen by the instructor: graph theory, critical path analysis, statistical inference, coding, game theory, and symmetry. 4 lectures. Prerequisite: Passing score on ELM examination, or an ELM exemption, or credit in MATH 104. Fulfills GE B1.

MATH 114 Intermediate Algebra Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of intermediate algebra. Not for baccalaureate credit. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 104.

MATH 116, 117 Pre-Calculus Algebra I, II (3) (3)

For MATH 116 and 117: GE B1

Pre-calculus college algebra without trigonometry. Special products and factoring, exponents and radicals. Fractional and polynomial equations. Matrices, determinants, and systems of equations. Polynomial, rational, exponential, and logarithmic functions. Graphing, inequalities, absolute value, and complex numbers. MATH 116 and MATH 117 are equivalent to MATH 118, but are taught at a slower pace. Upon completion of MATH 116 and MATH 117, a student will receive 4 units of GE credit for Area B1. Not open to students with credit in MATH 118. 3 lectures. **MATH 116** prerequisite: Passing score on ELM examination, or an ELM exemption, or credit in MATH 104. **MATH 117** prerequisite: MATH 116 with a grade of C- or better or consent of instructor.

MATH 118 Pre-Calculus Algebra (4) GE B1

Pre-calculus algebra without trigonometry. Special products and factoring, exponents and radicals. Fractional and polynomial equations. Matrices, determinants, and systems of equations. Polynomial, rational, exponential, and logarithmic functions. Graphing, inequalities, absolute value, and complex numbers. MATH 118 is equivalent to MATH 116 and MATH 117. Not open to students with credit in MATH 117. 4 lectures. Prerequisite: Completion of ELM requirement and passing score on appropriate Mathematics Placement Examination. Fulfills GE B1.

MATH 119 Pre-Calculus Trigonometry (4) GE B1

Rectangular and polar coordinates. Trigonometric functions, fundamental identities. Inverse trigonometric functions and relations. Vectors, complex numbers, conic sections, and analytic geometry. 4 lectures. Prerequisite: Completion of ELM requirement and passing score on appropriate Mathematics Placement Examination, or MATH 117, or MATH 118. Fulfills GE B1.

MATH 126, 127 Pre-Calculus Algebra Workshop I, II (1) (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of pre-calculus algebra. Credit/No Credit grading only. 1 laboratory. **MATH 126** corequisite: Concurrent enrollment in the associated section of MATH 116. **MATH 127** corequisite: Concurrent enrollment in the associated section of MATH 117.

MATH 128 Pre-Calculus Algebra Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of pre-calculus algebra. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 118.

MATH 129 Pre-Calculus Trigonometry Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of pre-calculus trigonometry. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 119.

MATH 141, 142, 143 Calculus I, II, III (4) (4) (4) GE B1

Limits, continuity, differentiation, integration. Techniques of integration, applications to physics, transcendental functions. Infinite sequences and series, vector algebra, curves. 4 lectures. **MATH 141** prerequisite: Completion of ELM requirement and passing score on appropriate Mathematics Placement Examination, or MATH 118 and high school trigonometry, or MATH 119. **MATH 142** prerequisite: MATH 141 with a grade of C- or better or consent of instructor. **MATH 143** prerequisite: MATH 142 with a grade of C- or better or consent of instructor. *Crosslisted as HNRS/MATH 141, 142, 143.* Each fulfills GE B1.

MATH 151, 152, 153 Calculus Workshop I, II, III (1) (1) (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of calculus. Credit/No Credit grading only. 1 laboratory. **MATH 151** corequisite: Concurrent enrollment in the associated section of MATH 141. **MATH 152** corequisite: Concurrent enrollment in the associated section of MATH 142. **MATH 153** corequisite: Concurrent enrollment in the associated section of MATH 143.

MATH 161, 162 Calculus for the Life Sciences I, II (4) (4) GE B1

Review of exponential, logarithmic, and trigonometric functions. Differential and integral calculus with applications to the biological sciences. Introduction to differential equations and mathematical modeling. Examples, exercises and applications to emphasize problems in life sciences. Not open to students with credit in MATH 141, 142, respectively. 4 lectures. **MATH 161** prerequisite: Completion of ELM requirement and passing score on appropriate Mathematics Placement Examination, or MATH 118. **MATH 162** prerequisite: MATH 161. Each fulfills GE B1.

MATH 171 Calculus for the Life Sciences Workshop I (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of calculus for the life sciences. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 161.

MATH 182 Calculus for Architecture and Construction Management (4) GE B1

Integral calculus with applications to architecture and construction management. The algebra of vectors. Polar, cylindrical, and spherical coordinate systems. Not open to students with credit in MATH 142. 4 lectures. Prerequisite: MATH 141. Fulfills GE B1.

MATH 192 Calculus for Architecture and Construction Management Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of calculus to architecture and construction management. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 182.

MATH 202 Orientation to the Mathematics Major (1) (CR/NC)

Career opportunities in the field of mathematics, preparing a field of study, and a survey of departmental facilities and procedures related to research, study and graduation. Credit/No Credit grading only. 1 lecture. Prerequisite: MATH 143.

MATH 206 Linear Algebra I (4)

Matrices, inverses, linear systems, determinants, eigenvalues, eigenvectors, vector spaces, linear transformations, applications. 4 lectures. Prerequisite: MATH 143.

MATH 211, 212 Computational Mathematics I, II (4) (4)

Fundamentals of procedural programming in C/C++ and selected applications to problems in integral and differential calculus, matrix analysis, geometry, and physics. 4 lectures. **MATH 211** prerequisite: MATH 141. **MATH 212** prerequisite: MATH 211.

MATH 221 Calculus for Business and Economics (4) GE B1

Polynomial calculus for optimization and marginal analysis, and elementary operations, models, and number theory. This class is designed for Liberal Studies majors. Other students will be admitted only by consent of instructor. 4 lectures. Prerequisite: Completion of ELM requirement and passing score on appropriate Mathematics Placement Examination, or MATH 118. Fulfills GE B1.

MATH 227 Mathematics for Elementary Teaching I (4) GE B1

Introduction to problem solving, set theory, number systems, arithmetic operations, models, and number theory. This class is designed for Liberal Studies majors. Other students will be admitted only by consent of instructor. 4 lectures. Prerequisite: Passing score on ELM examination, or an ELM exemption, or credit in MATH 104. Fulfills GE B1.

MATH 231 Calculus for Business and Economics Workshop (1) (CR/NC)

Facilitated study and discussion of the theory, problems, and applications of business calculus. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 221.

MATH 241 Calculus IV (4)

Partial derivatives, multiple integrals, introduction to vector analysis. 4 lectures. Prerequisite: MATH 143. *Crosslisted as HNRS/MATH 241.*

MATH 242 Differential Equations I (4)

Ordinary differential equations: first-order linear equations, separable equations, exact equations, second-order linear equations, nonhomogeneous equations, systems of first-order linear equations, systems of nonlinear equations, modeling and applications. Not open to students with credit in MATH 244. 4 lectures. Prerequisite: MATH 206 and MATH 241.

MATH 244 Linear Analysis I (4)

Separable and linear ordinary differential equations with selected applications; numerical and analytical solutions. Linear algebra: vectors in n -space, matrices, linear transformations, eigenvalues, eigenvectors, diagonalization; applications to the study of systems of linear differential equations. 4 lectures. Prerequisite: MATH 143. *Crosslisted as HNRS/MATH 244.*

MATH 248 Methods of Proof in Mathematics (4)

Methods of proof (direct, contradiction, conditional, contraposition); valid and invalid arguments. Examples from set theory. Quantified statements and their negations. Functions, indexed sets, set functions. Proofs in number theory, algebra, geometry and analysis. Proof by induction. Equivalence and well-defined operations and functions. The axiomatic method. 4 lectures. Prerequisite: MATH 143.

MATH 258 Methods of Proof in Mathematics Workshop (1) (CR/NC)

Facilitated study and discussion of the methods and techniques of proof in mathematics. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 248.

MATH 270 Selected Topics (1–4)

Directed group study of selected topics. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures. Prerequisite: Consent of instructor.

MATH 300 Technology in Mathematics Education (4)

Examination of existing hardware and software designed for educational uses. Discussion of mathematical topics appropriate for computer enhancement. Special methods and techniques for educational uses of computers. Emphasis on activity learning and applications. Computer as a classroom management device. 4 lectures. Prerequisite: MATH 330 or SCM 300, and MATH 142.

MATH 304 Vector Analysis (4) GE B6

Differential and integral calculus of vector-valued functions. Green's Theorem, Stokes' Theorem, and the Divergence Theorem. Applications and generalizations. 4 lectures. Prerequisite: MATH 206 or MATH 244, and MATH 241. Fulfills GE B6.

MATH 306 Linear Algebra II (4)

Inner product spaces, orthogonality, Fourier series and orthogonal bases, linear transformations and similarity, eigenvalues and diagonalization. 4 lectures. Prerequisite: MATH 241, and MATH 206 or MATH 244, and a C- or better in MATH 248, or consent of instructor.

MATH 316 Introduction to Linear Algebra Workshop II (1) (CR/NC)

Facilitated study and discussion of the methods and techniques of proof in linear algebra. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 306.

MATH 326 Mathematics and Visual Art (4) GE B5

Topics connecting mathematics and visual art including regular polygons, symmetry groups, repetition and pattern, perspective, straightedge and compass constructions, and origami. Examples of mathematical art including historic and contemporary art. 4 lectures. Prerequisite: Completion of GE Area B1 and a college course in art or design. Fulfills GE B5.

MATH 328, 329 Mathematics for Elementary Teaching II, III (4) (4)

Introduction to rational and real numbers, probability and counting techniques, statistics, and geometry. Computer applications. 4 lectures.

MATH 328 prerequisite: MATH 227 with a grade of C- or better or consent of instructor. **MATH 329** prerequisite: MATH 328.

MATH 330 Algebraic Thinking with Technology (4)

Algebraic concepts for elementary teachers. Mathematical patterns, equations and inequalities, linear and quadratic functions, exponential and logarithmic functions, systems of equations, roots of polynomials, factoring of polynomials, and right-triangle trigonometry. Computer applications. 4 lectures. Prerequisite: MATH 329.

MATH 335 Graph Theory (4)

Introduction to graph theory and its applications: isomorphism, paths and searching, connectedness, trees, tournaments, planarity, graph colorings, matching theory, network flow, adjacency and incidence matrices. Further topics to be selected from the theory of finite state machines, Ramsey theory, extremal theory, and graphical enumeration. 4 lectures. Prerequisite: MATH 248 or junior standing.

MATH 336 Combinatorial Mathematics (4)

Methods of enumerative combinatorics: sum, product, and division rules, bijective and recursive techniques, inclusion and exclusion, generating functions, and the finite difference calculus. Advanced topics to be selected from the theory of partitions, Polya theory, designs, and codes. 4 lectures. Prerequisite: MATH 248 or junior standing.

MATH 341 Theory of Numbers (4)

Properties of numbers. Euclid's Algorithm, greatest common divisors, diophantine equations, prime numbers, congruences, number theoretic functions, the quadratic reciprocity laws, primitive roots and indices. 4 lectures. Prerequisite: MATH 248 with a grade of C- or better or consent of instructor.

MATH 344 Linear Analysis II (4) GE B6

Linear methods applied to the solution of differential equations. Laplace transforms. Series solutions to ordinary differential equations. Orthogonality in n -space, Gram-Schmidt orthogonalization and least squares methods. Orthogonal bases in function spaces, Sturm-Liouville theory. Fourier series and transforms. Special functions of applied mathematics. 4 lectures. Prerequisite: MATH 206 and MATH 242, or MATH 241 and MATH 244. Fulfills GE B6.

MATH 350 Mathematical Software (4)

Problem-solving using mathematical software. 4 lectures. Prerequisite: MATH 206 or MATH 244, and MATH 241, and an introductory college-level programming course, or consent of instructor.

MATH 351 Typesetting with LaTeX (1) (CR/NC)

Preparing documents, especially mathematical ones, using LaTeX and AMS-LaTeX. Credit/No Credit grading only. 1 lecture. Prerequisite: Junior standing.

MATH 370 Putnam Exam Seminar (2)

Directed group study of mathematical problem-solving techniques. Open to undergraduate students only. Class members are expected to participate in the annual William Lowell Putnam Mathematical Competition. Course may be repeated up to eight units. 2 seminars. Prerequisite: Consent of instructor.

MATH 371 Math Modeling Seminar (2)

Directed group study of mathematical modeling techniques. Open to undergraduate students only. Class members are expected to participate in the annual Mathematical Competition in Modeling. Total credit limited to 8 units. 2 seminars. Prerequisite: Consent of instructor.

MATH 372 Mathematical Community Service Projects (2) (CR/NC)

Directed group mathematical research in support of volunteer community service projects. Total credit limited to 8 units. 2 seminars. Prerequisite: consent of instructor and consent of department chair.

MATH 400 Special Problems for Advanced Undergraduates (1-4)

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 8 units. Prerequisite: Junior standing and consent of department chair.

MATH 404 Introduction to Differential Geometry (4)

Theory of curves and surfaces in space. Topics such as Frenet formulas, curvature, geodesics, Cartan structural equations, Gauss-Bonnet Theorem. 4 lectures. Prerequisite: MATH 304.

MATH 406 Linear Algebra III (4)

Complex vector spaces, unitary and self-adjoint matrices, Spectral Theorem, Jordan canonical form. Selected topics in linear programming, convexity, numerical methods, and functional analysis. 4 lectures. Prerequisite: MATH 306.

MATH 408, 409 Complex Analysis I, II (4) (4) MATH 408: GE B6

Elementary analytic functions and mappings. Cauchy's Integral Theorem; Poisson's Integral Formula. Taylor and Laurent series, theory of residues, and the evaluation of integrals. Harmonic functions, conformal mappings. 4 lectures. **MATH 408** prerequisite: MATH 242, or MATH 241 and MATH 244. **MATH 408** fulfills GE B6. **MATH 409** prerequisite: MATH 408.

MATH 412 Introduction to Analysis I (4)

Introduction to concepts and methods basic to real analysis. Topics such as the real number system, sequences, continuity, uniform continuity and differentiation. 4 lectures. Prerequisite: MATH 306.

MATH 413, 414 Introduction to Analysis II, III (4) (4)

A continuation of Introduction to Analysis I covering such topics as integration, infinite series, uniform convergence and functions of several variables. Highly recommended for students planning to enter graduate programs or secondary teaching and those interested in applied mathematics. 4 lectures. **MATH 413** prerequisite: MATH 412. **MATH 414** prerequisite: MATH 413.

MATH 416 Differential Equations II (4)

Qualitative theory of ordinary differential equations: Existence and Uniqueness Theorem, phase portraits, limit sets, stability of fixed points and periodic orbits, energy functions, Poincaré-Bendixson Theorem, Poincaré maps, bifurcations, attractors, chaos. 4 lectures. Prerequisite: MATH 206 and MATH 242, or MATH 241 and MATH 244.

MATH 418 Partial Differential Equations (4)

Mathematical formulation of physical laws. Separation of variables. Orthogonal functions and generalized Fourier series. Bessel functions, Legendre polynomials. Sturm-Liouville problem. Boundary value problems; nonhomogeneous techniques. Applications to heat flow, potential theory, vibrating strings and membranes. 4 lectures. Prerequisite: MATH 344 or consent of instructor. Recommended: MATH 304.

MATH 419 Introduction to the History of Mathematics (4)

Evolution of mathematics from earliest to modern times. Major trends in mathematical thought, the interplay of mathematical and technological innovations, and the contributions of great mathematicians. Appropriate for prospective and in-service teachers. 4 lectures. Prerequisite: MATH 248 with a grade of C- or better and at least one upper division course in mathematics, or consent of instructor.

MATH 422 Introduction to Analysis I Workshop (1) (CR/NC)

Facilitated study and discussion of the methods and techniques of proof in introductory analysis. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 412.

MATH 423 Advanced Mathematics for Teaching (4)

Introduction to mathematics education research and advanced exploration of the mathematics taught in California's public high schools and middle schools through problem analysis, concept analysis, and problem connections. 4 lectures. Prerequisite: MATH 442 and MATH 481.

MATH 424 Organizing and Teaching Mathematics (4) (CR/NC)

Organization, selection, presentation, application and interpretation of subject matter in mathematics. Introduction to current issues in mathematics education. For students who will be teaching in secondary schools. Credit/No Credit grading only. 4 lectures. Prerequisite: Acceptance into the Mathematics Single Subject Credential Program, or senior standing in the mathematics major, or consent of instructor.

MATH 425 Mathematics Student Teaching Seminar (1) (CR/NC)

Principles and practice in effective teaching of mathematics at the middle and high school level, learning theories, curriculum content and structure, classroom issues, and the teaching profession. Credit/No Credit grading only. Total credit limited to 2 units. 1 seminar. Prerequisite: Acceptance into Step II of the Single Subject Credential Program in Mathematics. Concurrent: EDUC 469 or EDUC 479.

MATH 435 Discrete Mathematics with Applications I (4)

Methods of discrete mathematics with applications. Generating functions and Lagrange inversion, partition theory, permutation statistics and q-analogues, posets and Möbius inversion. Additional topics including lattice paths and basic hypergeometric series. 4 lectures. Not open to students with credit in MATH 530. Prerequisite: MATH 248 with a grade of C- or better and MATH 336, or consent of instructor.

MATH 436 Discrete Mathematics with Applications II (4)

Methods of discrete mathematics with applications. Polya theory, codes, designs, matroids, the combinatorics of symmetric functions, and tableaux combinatorics. Additional topics including transversals and Latin squares, asymptotics, and discrete probability theory. 4 lectures. Not open to students with credit in MATH 531. Prerequisite: MATH 435; corequisite: MATH 482.

MATH 437 Game Theory (4)

Development of the mathematical concepts, techniques, and models used to investigate optimal strategies in competitive situations; games in extensive, normal, and characteristic form, Nash equilibrium points and Nash Bargaining Model. 4 lectures. Prerequisite: MATH 206 or MATH 244, and MATH 248 with a grade of C- or better, or consent of instructor.

MATH 440 Topology I (4)

Introduction to general topological spaces with emphasis on surfaces and manifolds. Open and closed sets, continuity, compactness, connectedness. Quotient spaces. 4 lectures. Not open to students with credit in MATH 540. Prerequisite: MATH 412; corequisite: MATH 481.

MATH 441 Topology II (4)

Introduction to general topological spaces with emphasis on surfaces and manifolds. Fundamental group. Triangulations of spaces, classification of surfaces. Other topics may include covering spaces, simplicial homology, homotopy theory and topics from differential topology. 4 lectures. Not open to students with credit in MATH 541. Prerequisite: MATH 440.

MATH 442 Euclidean Geometry (4)

Foundations of Euclidean geometry, finite geometries, congruence, similarities, polygonal regions, circles and spheres. Constructions, mensuration, the parallel postulate. Appropriate for prospective and in-service mathematics teachers. 4 lectures. Prerequisite: MATH 248 with a grade of C- or better or consent of instructor. Recommended: MATH 300 or familiarity with dynamic geometry software.

MATH 443 Modern Geometries (4)

Non-Euclidean and projective geometries. Properties of parallels, biangles, Saccheri and Lambert quadrilaterals, angle-sum and area. Limiting curves, hyperbolic trigonometry, duality, perspectivity, quadrangles, fundamental theorems of projective geometry, conics. 4 lectures. Prerequisite: MATH 442.

MATH 451 Numerical Analysis I (4)

Topics in interpolation and approximation methods, initial value problems, and boundary value problems of ordinary differential equations. 4 lectures.

Prerequisite: MATH 206 and MATH 242, or MATH 241 and MATH 244, and an introductory college-level programming course.

MATH 452 Numerical Analysis II (4)

Numerical techniques for solving partial differential equations of the parabolic, hyperbolic and elliptic type. Further topics in approximation theory. 4 lectures. Prerequisite: MATH 451.

MATH 453 Numerical Optimization (4)

Algorithms for solving optimization problems that cannot be solved analytically. Descent algorithms including exact and practical line-searches, steepest descent method, and Newton and quasi-Newton methods for unconstrained minimization. Optimality conditions for constrained optimization, linear programming. Projection and Lagrangian methods, and interior point methods for constrained minimization. 4 lectures. Prerequisite: MATH 306 and MATH 451. *Formerly MATH 431.*

MATH 459 Senior Seminar (4)

Written and oral analyses and presentations by students on topics from advanced mathematics and mathematical modeling. 4 seminars. Prerequisite: MATH 306, and completion of at least two additional upper-division courses in the math major.

MATH 460 Applied Mathematics Senior Seminar (4)

Written and oral analyses and presentations by students on topics in applied mathematics, including applications to sustainability. Construction of mathematical models for physical and biological problems, with analysis and interpretation of the solutions of these models using both analytical and numerical techniques. 4 seminars. Prerequisite: MATH 306, MATH 344, and MATH 451.

MATH 461, 462 Senior Project I, II (2) (2)

Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results are presented in a formal report. Minimum 120 hours total time. **MATH 461** prerequisite: MATH 459 or MATH 460. **MATH 462** prerequisite: MATH 461.

MATH 470 Selected Advanced Topics (1-4)

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures. Prerequisite: Consent of instructor.

MATH 474 Advanced Topics in Geometry and Topology (1)

Exploration of advanced topics and problems in geometry and topology through reading, writing and oral presentations. The Schedule of Classes will list the specific topic as a subtitle. Total credit limited to 6 units. 1 seminar. Prerequisite: MATH 248 and consent of instructor. Recommended: MATH 404 and MATH 440. *New course, effective Winter 2012*

MATH 481, 482 Abstract Algebra I, II (4) (4)

Introduction to the study of algebraic structures, including groups, rings and fields. 4 lectures. **MATH 481** prerequisite: MATH 306 or MATH 341. **MATH 482** prerequisite: MATH 481.

MATH 485 Cooperative Education Experience (6) (CR/NC)

Part-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. No major credit allowed; total credit limited to 12 units. Credit/No Credit grading only. Prerequisite: Consent of instructor.

MATH 491 Abstract Algebra I Workshop (1) (CR/NC)

Facilitated study and discussion of the methods and techniques of proof in abstract algebra. Credit/No Credit grading only. 1 laboratory. Corequisite: Concurrent enrollment in the associated section of MATH 481.

MATH 495 Cooperative Education Experience (12) (CR/NC)

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. No major credit allowed; total credit limited to 12 units. Credit/No Credit grading only. Prerequisite: Consent of instructor.

MATH 500 Individual Study (1-4)

Individual research or advanced study planned and completed under the direction of a departmental faculty member. Open only to graduate students demonstrating ability to do independent work. Total credit limited to 12 units. Prerequisite: Graduate standing and consent of department chair.

MATH 501, 502 Methods of Applied Mathematics I, II (4) (4)

Introduction to advanced methods of mathematics useful in the analysis of engineering problems. Theory of vector fields, Fourier analysis, Sturm-Liouville theory, functions of a complex variable. Selected topics in asymptotic analysis, special functions, perturbation theory. Not open to students in math major or master's degree program in mathematics. **MATH 501**: Distance Learning Lab fee may be required—see the Schedule of Classes. 4 lectures. **MATH 501** prerequisite: MATH 344 or AERO 300, and graduate standing. **MATH 502** prerequisite: MATH 501.

MATH 504 Mathematical Topics for Teachers (1-4) (CR/NC)

Mathematical topics for practicing credentialed teachers. Professional growth through improvement of teachers' mathematical content knowledge and pedagogical approaches using technology, discussion, reflection, and hands-on activities. Content will vary according to teaching level. The Schedule of Classes will list topic selected. Total credit limited to 12 units. Not open to students in math major or master's degree program in mathematics. Credit/No Credit grading only. 1-4 activities. Prerequisite: Multiple Subject or Single Subject teaching credential or consent of instructor.

MATH 505 Graduate Teaching Seminar (1) (CR/NC)

Principles and practice in effective teaching of college-level mathematics. Issues related to present and future teaching experiences, including time management, professionalism, student assessment, grading, classroom management, and qualities of good mathematics teachers. Reflection on individual teaching, and consideration of improvements in instruction. Credit/No Credit grading only. Total credit limited to 2 units. 1 seminar. Prerequisite: Graduate standing.

MATH 520, 521 Applied Analysis I, II (4) (4)

Advanced mathematical methods of analysis in science and engineering, integrated with modeling of physical phenomena. Topics include applications of complex analysis, Fourier analysis, ordinary and partial differential equations. Additional topics to be drawn from perturbation methods, asymptotic analysis, dynamical systems, numerical methods, optimization, and the calculus of variations. 4 lectures. **MATH 520** prerequisite: MATH 408, MATH 412 and graduate standing. Recommended: MATH 418. **MATH 521** prerequisite: MATH 520.

MATH 530 Discrete Mathematics with Applications I (4)

Methods of discrete mathematics with applications. Generating functions and Lagrange inversion, partition theory, permutation statistics and q-analogues, posets and Möbius inversion. Additional topics including lattice paths and basic hypergeometric series. 4 lectures. Not open to students with credit in MATH 435. Prerequisite: MATH 248 with a grade of C- or better and MATH 336 and graduate standing, or consent of instructor.

MATH 531 Discrete Mathematics with Applications II (4)

Methods of discrete mathematics with applications. Polya theory, codes, designs, matroids, the combinatorics of symmetric functions, and tableaux combinatorics. Additional topics including transversals and Latin squares, asymptotics, and discrete probability theory. 4 lectures. Not open to students with credit in MATH 436. Prerequisite: MATH 530; corequisite: MATH 482.

MATH 540 Topology I (4)

Introduction to general topological spaces with emphasis on surfaces and manifolds. Open and closed sets, continuity, compactness, connectedness. Quotient spaces. 4 lectures. Not open to students with credit in MATH 440. Prerequisite: MATH 412 and graduate standing; corequisite: MATH 481.

MATH 541 Topology II (4)

Introduction to general topological spaces with emphasis on surfaces and manifolds. Fundamental group. Triangulations of spaces, classification of surfaces. Other topics may include covering spaces, simplicial homology, homotopy theory and topics from differential topology. 4 lectures. Not open to students with credit in MATH 441. Prerequisite: MATH 540 and graduate standing.

MATH 550 Real Analysis (4)

Introduction to Lebesgue measure and integration, convergence theorems, L_1 spaces, Radon-Nikodym Theorem and Fubini's Theorem. 4 seminars.
Prerequisite: Satisfactory completion of the Graduate Written Examination in Analysis or consent of the Graduate Committee.

MATH 560 Field Theory (4)

Polynomial rings, field extensions, normal and separable extensions, automorphisms of fields, fundamental theorem of Galois theory, solvable groups, solution by radicals, insolubility of the quintic. 4 lectures.
Prerequisite: Satisfactory completion of the Graduate Written Examination in Algebra or consent of the Graduate Committee.

MATH 570 Selected Advanced Topics (1-4)

Directed group study of selected topics for graduate students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1-4 lectures. Prerequisite: Graduate standing and consent of instructor.

MATH 580 Seminar (1-4)

Built around topics in advanced mathematics chosen according to the common interests and needs of the students enrolled. Each seminar will have a subtitle according to the nature of the content. Total credit limited to 12 units. 1-4 seminars. Prerequisite: Graduate standing and consent of instructor.

MATH 599 Thesis (3)

Serious research endeavor devoted to the development, pedagogy or learning of mathematics. Course to be taken twice for a total of 6 units. Prerequisite: Graduate standing and consent of instructor. *Formerly MATH 596.*