MATH-MATHEMATICS (MATH)

MATH 101. General Supplemental Instruction I
1 Credit
Corequisite(s): MATH 120.

MATH 102. General Supplemental Instruction II
1 Credit
Corequisite(s): MATH 121G.

MATH 107. Topics in Mathematics
1-3 Credits
Topics to be announced in the Schedule of Classes. Maximum of 3 credits per semester. Total credit not to exceed 6 credits. Community Colleges only.
Prerequisite: consent of instructor.

MATH 111. Fundamentals of Elementary Mathematics I
3 Credits
Numbers and the four operations of arithmetic. Understanding and comparing multiple representations of numbers and operations, in particular how these representations build from whole numbers to integers to fractions and decimals. Applying properties of numbers and operations in contextual situations. Reasoning, communicating, and problem solving with numbers and operations. Applications to ratio, and connections with algebra. Taught primarily through student activities and investigations. Restricted to: EDUC,EPAR, ED,ECED majors.
Prerequisite(s): ENGL 111G and grade of C or better in MATH 120.

MATH 112G. Fundamentals of Elementary Math II
3 Credits
Geometry and measurement. Multiple approaches to solving problems and understanding concepts in geometry. Analyzing and constructing two- and three-dimensional shapes. Measureable attributes, including angle, length, area, and volume. Understanding and applying units and unit conversions. Transformations, congruence, and symmetry. Scale factor and similarity. Coordinate geometry and connections with algebra. Reasoning and communicating about geometric concepts. Taught primarily through student activities and investigations.
Prerequisite(s): C or better in MATH 111.

MATH 120. Intermediate Algebra
3 Credits
Linear and algebraic functions as they arise in real world problems. Exponential and logarithmic functions. Equations and inequalities and their solutions considered symbolically, graphically and numerically.
Prerequisite: adequate score on the Mathematics Placement Examination.

MATH 121G. College Algebra
3 Credits
Fundamental concepts of functions, including algebraic and graphical properties. Fitting functions to data. Finding zeroes and extreme values. Solving systems of equations.
Prerequisites: Adequate math placement score or C or better in MATH 120.

MATH 142G. Calculus for the Biological and Management Sciences
3 Credits (2+2P)
Review of functions. Derivatives, exponential and logarithmic functions, antiderivatives and indefinite integrals, basic ordinary differential equations and growth models, with an emphasis on applications. Includes a significant writing component.
Prerequisite(s): C or better in MATH 121G.

MATH 190G. Trigonometry and Precalculus
4 Credits (3+2P)
Elementary functions used in the sciences with emphasis on trigonometric functions and their inverses. Polar coordinates. Complex numbers and Euler’s formula. Analytic geometry and vectors.
Prerequisite: adequate score on Mathematics placement exam or a C or better in MATH 121G.

MATH 191G. Calculus and Analytic Geometry I
4 Credits
Limits and continuity, theory and computation of derivatives, applications of derivatives, extreme values, critical points, derivative tests, L'Hopital's Rule.
Prerequisite(s): C or better in MATH 190G.

MATH 192G. Calculus and Analytic Geometry II
4 Credits
Riemann sums, the definite integral, antiderivatives, fundamental theorems, techniques of integration, applications of integrals, improper integrals, Taylor polynomials, sequences and series, power series and Taylor series.
Prerequisite(s): C or better in MATH 191G.

MATH 192GH. Calculus and Analytic Geometry II Honors
4 Credits (3+1P)
A more advanced treatment of the material of MATH 192G with additional topics. Consent of Instructor required. Restricted to Las Cruces campus only.
Prerequisite(s): Consent of Department.

MATH 200. Directed Study
1-3 Credits
May be repeated for a maximum of 6 credits. Graded S/U.
Prerequisite: consent of the instructor.

MATH 210G. Mathematics Appreciation
3 Credits
Mathematics and its role in the development and maintenance of civilization.
Prerequisites: High school algebra, and an adequate score on the Mathematics Placement Examination.

MATH 215. Fundamentals of Elementary Mathematics III
3 Credits
Probability, statistics, ratios, and proportional relationships. Experimental and theoretical probability. Collecting, analyzing, and displaying data, including measurement data. Multiple approaches to solving problems involving proportional relationships, with connections to number and operation, geometry and measurement, and algebra. Understanding data in professional contexts of teaching. Taught primarily through student activities and investigations.
Prerequisite(s): C or better in MATH 112.

MATH 235. Calculus for the Technical Student I
3 Credits
Intuitive differential and integral calculus with applications to engineering.
Prerequisite: C or better in MATH 190G.
MATH 236. Calculus for the Technical Student II
3 Credits
A continuation and extension of the material in MATH 235.
Prerequisite: C or better in MATH 235 or in MATH 192G.

MATH 279. Introduction to Higher Mathematics
3 Credits
Logic; sets, relations, and functions; introduction to mathematical proofs.
Prerequisite(s): C- or better in MATH 192.

MATH 280. Introduction to Linear Algebra
3 Credits
Systems of equations, matrices, vector spaces and linear transformations. Applications to computer science.
Prerequisite(s): Grade of C- or better in MATH 192G.

MATH 291G. Calculus and Analytic Geometry III
3 Credits
Vector algebra, directional derivatives, approximation, max-min problems, multiple integrals, applications, cylindrical and spherical coordinates, change of variables.
Prerequisite: grade of C or better in MATH 192G.

MATH 300. Readings
1-3 Credits
A selection of readings and reports in the mathematical sciences, the breadth and depth of which is deemed to fit the needs of the student. Graded S/U.
Prerequisite: consent of instructor.

MATH 313. Fundamentals of Algebra and Geometry I
3 Credits (3+1P)
Covers algebra combined with geometry based on measurements of distance (metric geometry). Secondary mathematics education majors may take course as a math elective. MATH 313 does not substitute for other required math courses. Does not fulfill requirements for major in mathematics.
Prerequisites: MATH 111 and MATH 112G.

MATH 316. Calculus with Hands-on Applications
3 Credits
This course, primarily for prospective teachers, is taught in an interactive laboratory format. Students design and construct physical objects for which the planning stage requires calculus techniques. All numerical computations are carried out on graphing calculators. Meets simultaneously with MATH 516, primarily for practicing teachers. Secondary math education majors may take course as a math elective. MATH 316 does not fulfill requirements for majors in mathematics. Consent of instructor required.

MATH 331. Introduction to Modern Algebra
3 Credits
Elements of abstract algebra, including groups, rings and fields.
Prerequisite: C or better in MATH 279 and MATH 280.

MATH 332. Introduction to Analysis
3 Credits
Development of the real numbers, a rigorous treatment of sequences, limits, continuity, differentiation, and integration.
Prerequisite: C or better in MATH 192G and MATH 279.

MATH 377. Introduction to Numerical Methods
3 Credits
Basic numerical methods for interpolation, approximation, locating zeros of functions, integration, and solution of linear equations. Computer-oriented methods will be emphasized.
Prerequisite: grade of C or better in MATH 192G and some programming experience.

MATH 391. Vector Analysis
3 Credits
Calculus of vector valued functions, Green's and Stokes' theorems and applications.
Prerequisite: grade of C or better in MATH 291G.

MATH 392. Introduction to Ordinary Differential Equations
3 Credits
Introduction to differential equations and dynamical systems with emphasis on modeling and applications. Basic analytic, qualitative and numerical methods. Equilibria and bifurcations. Linear systems with matrix methods, real and complex solutions.
Prerequisite: C or better in MATH 192G or B or better in MATH 236.

MATH 400. Undergraduate Research
1-3 Credits
May be repeated for a maximum of 6 credits. Graded S/U.
Prerequisite: consent of faculty member.

MATH 401. Special Topics
1-3 Credits (1-3)
Specific subjects to be announced in the Schedule of Classes. May be used to fulfill a course requirement for the mathematics major. May be repeated up to 12 credits. Consent of Instructor required.
Prerequisite(s): Consent of instructor.

MATH 411V. Great Theorems: The Art of Mathematics
3 Credits
Adopts the view of mathematics as art, using original sources displaying the creation of mathematical masterpieces from antiquity to the modern era. Original sources are supplemented by cultural, biographical, and mathematical history placing mathematics in a broad human context.
Prerequisites: Grades of B or better in MATH 192G and any upper division MATH/STAT course, with overall GPA of 3.2 or better, or consent of instructor.

MATH 421. Financial Mathematics I
3 Credits
Types of derivatives, forwards and futures, options, returns and payoffs, Arrow-Debre, complete and incomplete markets, the one period model, the binomial option pricing model, binomial trees, martingales and sub martingales, Brownian motion, stochastic integrals, the Ito integral, Ito's dilemma, the Black-Scholes model, the Black-Scholes formula, European options, American options, free boundary problems, variational inequalities. This course is offered simultaneously with MATH 521.
Prerequisite(s): Consent of instructor.

MATH 422. Financial Mathematics II
3 Credits
Bonds, swaps, exotic options, barrier options, Asian options, look back options, options with transaction costs, Fokker Plank theory, computing expectations, the Heath-Jarrow- Morton theorem, the Ho-Lee model, stochastic volatility models, exponential-affine models, numerical methods. This course is offered simultaneously with MATH 522.
Prerequisite: C or better in MATH 421 or consent of instructor.
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MATH 506. Lattice Theory
3 Credits
Same as MATH 466 with additional assignments for graduate students.

MATH 507. Applications of Modern Algebra
3 Credits
Taught with MATH 457 with additional work for graduate students. May be repeated up to 9 credits.

MATH 509. Information Theory
3 Credits
This class is a study of Shannon’s measure of information and discusses mutual information, entropy, and channel capacity, the noiseless source coding theorem, the noisy channel coding theorem, channel coding and random coding bounds, rate-distortion theory, and data compression. Restricted to: Main campus only. Crosslisted with: E E 586 Prerequisite(s): E E 571 or STAT 515.

MATH 511. Fundamentals of Elementary Mathematics I
3 Credits (3+1P)
Topics from real numbers, geometry, measurement, and algorithms, incorporating calculator technology. Intended for K-8 teachers. As part of course students mentor MATH 111 undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 512. Fundamentals of Elementary Mathematics II
3 Credits (3+1P)
Real numbers, geometry, and statistics, incorporating calculator technology. Intended for K-8 teachers. Students serve as mentors to MATH 112 undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 513. Fundamentals of Algebra and Geometry I
3 Credits (3+1P)
Algebra and metric geometry, incorporating appropriate calculator technology. Intended for K-8 teachers. Students serve as mentors to MATH 313 undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 516. Calculus with Hands-on Application
3 Credits
This course, primarily for in-service teachers, is taught in an interactive laboratory format. Students design and construct physical objects for which the planning stage requires calculus techniques. All numerical computations are carried out on graphing calculators. Meets simultaneously with Math 316, primarily for prospective teachers. Does not fulfill degree requirements for M.S. in Mathematics. Prerequisite(s): MATH 511 and MATH 512 or consent of instructor.

MATH 517. Complex Variables
3 Credits
Same as MATH 471 with additional work for graduate students.

MATH 518. Fourier Series and Boundary Value Problems
3 Credits
Same as MATH 472 with additional work for graduate students.

MATH 519. Calculus of Variations and Optimal Control
3 Credits
Same as MATH 473 with additional work for graduate students.

MATH 521. Financial Mathematics I: Portfolio Optimization
3 Credits
Complete and incomplete markets, optimal investment paths, dynamic optimization, the Black-Scholes model, European options, American options. May be repeated up to 3 credits. Prerequisite(s): STAT 515.

MATH 522. Financial Mathematics II
3 Credits

MATH 523. Numerical Optimization and Applications to Financial Mathematics
3 Credits
Dynamic optimization of a monopolist, trading off inflation and unemployment, the optimal adjustment of labor demand, infinite planning horizon, the optimal investment path of a firm, the optimal social saving behavior; phase-diagram analysis, optimal control theory, the political business cycle, the dynamics of a revenue-maximizing firm, economic examples of state-space constraints. This course is offered simultaneously with MATH 423. Prerequisite: MATH 521.

MATH 525. Advanced Linear Algebra
3 Credits
Same as MATH 481 with additional work for graduate students. May be repeated up to 3 credits.

MATH 527. Introduction to Real Analysis I
3 Credits
Same as MATH 491 with additional work for graduate students.

MATH 528. Introduction to Real Analysis II
3 Credits
Same as MATH 492 with additional work for graduate students.

MATH 530. Special Topics
1-3 Credits
Specific subjects to be announced in the Schedule of Classes. May be for unlimited credit with approval of the department.

MATH 531. Ordinary Differential Equations
3 Credits
Linear algebra and linear ordinary differential equations, existence and uniqueness of solution, smooth dependence on initial conditions, flows, introduction to smooth dynamical systems. May be repeated up to 3 credits. Prerequisite(s): MATH 527, or consent of instructor.

MATH 532. Partial Differential Equations
3 Credits
The basic equations of mathematical physics. Elliptic, hyperbolic, and parabolic equations. Characteristic surfaces. Well-posed problems. May be repeated up to 3 credits. Prerequisite(s): MATH 527 or consent of instructor.

MATH 540. Directed Reading
1-6 Credits
May be repeated for a maximum of 6 credits. Consent of instructor required. Graded: S/U.

MATH 541. Topology I
3 Credits
Connectedness and compactness of topological spaces, introduction to the quotient topology, elementary homotopy theory; the fundamental group, the Seifert-van Kampen theorem. Prerequisite(s): MATH 525 and MATH 528, or consent of instructor.
MATH 542. Topology II
3 Credits
Covering spaces and their classification, singular homology, degree theory, Brouwer's fixed point theorem, CW-complexes and cellular homology, and other applications.
Prerequisite(s): MATH 541 or consent of instructor.

MATH 555. Differentiable Manifolds
3 Credits
Differentiable structures, tangent bundles, vector fields and differential equations. Additional topics may include differential forms, De Rham cohomology, Riemannian geometry, and topics chosen by the instructor. May be repeated for a maximum of 9 credits. Consent of instructor required.
Prerequisite(s): MATH 525 and MATH 528, or consent of instructor.

MATH 557. Axiomatic Set Theory
3 Credits
A detailed study of Zermelo-Fraenkel and Bernays set theories.
Prerequisite: MATH 504 or equivalent.

MATH 562. History and Theories of Mathematics Education
3 Credits
A study of the history of the mathematics taught in American schools, including an examination of authentic original textbooks and the changes in their content and the approach to the subject over time, together with writings of people who have influenced the development and changes of mathematics education. Theories of learning mathematics, and current issues in mathematics education.
Prerequisite(s): Restricted to graduate students.

MATH 563. Algebra with Connections
3 Credits
Connections between Algebra and other K-12 curriculum strands, especially Geometry and Probability / Data Analysis. Apply algebraic modeling and reasoning to a variety of mathematical problem solving situations. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 564. From Number to Algebra
3 Credits
The progression from Number to Algebra in the K-12 curriculum as a concrete-to-abstract progression. Key concepts considered across the grade levels include the different uses of variables, equivalence in different contexts, patterns, and ratios. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 566. Data Analysis with Applications
3 Credits
Statistical concepts and terminology in professional uses of data by teachers, such as standardized test score reports and educational research; visual displays of data; measures of variation and central tendency; consideration of how K-12 topics in Data Analysis are developed from one grade level to the next. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 567. From Measurement to Geometry
3 Credits
The progression from Measurement to Geometry in the K-12 curriculum as a concrete-to abstract progression. Important concepts such as angle, length, and area progress from concrete, measurable situations to more abstract problems which require reasoning and proof. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 568. Using Number Throughout the Curriculum
3 Credits
Understand number concepts more deeply by seeing many examples of those concepts applied in other content strands. Develop mathematical knowledge and understanding to build a repertoire of ways for students to practice and review basic number skills and concepts as part of later, more advanced courses. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 569. Geometry with Connections
3 Credits
Connections between Geometry and other K-12 curriculum strands, especially Algebra and Probability / Data Analysis. Address key attributes of geometric concepts by considering their connections within and across grade levels. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 581. Algebra 1
3 Credits
Examines groups, commutative rings, solvability of polynomials, Galois theory, ruler and compass constructions.
Prerequisite/corequisite: MATH 525.

MATH 582. Algebra II
3 Credits
Group actions, fundamental theorem of finite Abelian groups, Sylow theorems, solvable groups, noncommutative rings, Noetherian rings, unique factorization domains, modules, tensor products.
Prerequisite: MATH 581.

MATH 583. Introduction to Commutative Algebra and Algebraic Geometry
3 Credits
Introduction to the basic notions and techniques of modern algebraic geometry, including the necessary commutative algebra foundation. Topics likely to include algebraic and projective varieties, Nullstellensatz, morphisms, rational and regular functions, local properties. Other topics may include Noether normalization, dimension theory, singularities, sheaves, schemes, Grobner bases. May be repeated up to 9 credits.
Prerequisite(s): MATH 581 or consent of instructor.

MATH 584. Representation Theory
3 Credits
Topics from representation theory of finite or infinite groups. May be repeated for a maximum of 9 credits.
Prerequisite: consent of instructor.

MATH 585. Universal Algebra
3 Credits
Universal algebra and category theory. Theorems of Birkhoff and Tarski relating equational classes, free algebras and their construction through homomorphisms, subalgebras and products. Topics from model theory, sheaf theory and representation by subdirect products. May be repeated for a maximum of 6 credits.
Prerequisite: consent of instructor.
MATH 586. Nonlinear Dynamics I
3 Credits
Introduction to nonlinear dynamics and deterministic chaos. Core topics include stability and bifurcations; chaos in one dimensional maps; universality and renormalization group. Further topics include symbolic dynamics, fractals, sensitive dependence on initial data, self-organization and complexity and cellular automata. Knowledge of differential equations and linear algebra is desired. May be repeated up to 6 credits.

MATH 591. Complex Analysis I
3 Credits
Rigorous treatment of complex differentiation and integration, properties of analytic functions, series and Cauchy's integral representations. May be repeated up to 3 credits.
Prerequisite(s): MATH 528, or consent of instructor.

MATH 593. Measure and Integration
3 Credits
Measure spaces, measurable functions, extension and decomposition theorems for measures, integration on measure spaces, absolute continuity, iterated integrals.
Prerequisite: MATH 528 or consent of instructor.

MATH 594. Real Analysis
3 Credits
Differentiation, Lp spaces, Banach spaces, measure and topology, other selected topics.
Prerequisite: MATH 593.

MATH 599. Master's Thesis
15 Credits
Thesis.

MATH 600. Doctoral Research
1-15 Credits
Research.

MATH 643. Topology III
3 Credits
Topics may include higher homotopy groups, fibrations, cohomology operations and obstruction theory, spectral sequences, or others chosen by instructor. May be repeated for a maximum of 9 credits.
Prerequisites: MATH 542 or consent of instructor.

MATH 683. Homological Algebra
3 Credits
Basic topics in homological algebra and category theory. May be repeated for a maximum of 9 credits.
Prerequisite: MATH 542 or MATH 582 or consent of instructor.

MATH 695. Introduction to Functional Analysis I
3 Credits
Banach spaces. The three basic principles: uniform boundedness principle, closed graph/open mapping theorems, Hahn-Banach theorem. May be repeated up to 3 credits.
Prerequisite(s): MATH 594, or consent of instructor.

MATH 698. Selected Topics
1-15 Credits
Selected topics.

MATH 700. Doctoral Dissertation
1-15 Credits
Dissertation.