

# MATH - MATHEMATICS (MATH)

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## MATH 102 Algebra

**Credits 3. 3 Lecture Hours.**

(MATH 1314, 1414) Algebra. Sets, structure of number system; absolute values, solution sets of linear and nonlinear equations, of systems of equations, and of inequalities; relations and functions, graphical representations, graphical representations, progressions, mathematical induction, determinants; also taught at Galveston campus.

## MATH 140 Mathematics for Business and Social Sciences

**Credits 3. 3 Lecture Hours.**

(MATH 1324) Mathematics for Business and Social Sciences. Application of common algebraic functions, including polynomial, exponential, logarithmic and rational, to problems in business, economics and the social sciences; includes mathematics of finance, including simple and compound interest and annuities; systems of linear equations; matrices; linear programming; and probability, including expected value. Only one of the following will satisfy the requirements for a degree: MATH 140 or MATH 168.

**Prerequisite:** High school algebra I and II and geometry; also taught at Galveston campus.

## MATH 142 Business Calculus

**Credits 3. 3 Lecture Hours.**

(MATH 1325) Business Calculus. Limits and continuity; techniques and applications of derivatives including curve sketching and optimization; techniques and applications of integrals; emphasis on applications in business, economics, and social sciences. Only one of the following will satisfy the requirements for a degree: MATH 131, MATH 142, MATH 147, MATH 151 or MATH 171.

**Prerequisites:** MATH 140 or MATH 150, or equivalent or acceptable score on Texas A&M University math placement exam; also taught at Galveston campus.

## MATH 147 Calculus I for Biological Sciences

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

Introduction to differential calculus in a context that emphasizes applications in the biological sciences. Only one of the following will satisfy the requirements for a degree: MATH 131, MATH 142, MATH 147, MATH 151 or MATH 171.

**Prerequisite:** MATH 150 or equivalent or acceptable score on TAMU Math Placement Exam; also taught at Galveston campus.

## MATH 148 Calculus II for Biological Sciences

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

Introduction to integral calculus in a context that emphasizes applications in the biological sciences; ordinary differential equations and analytical geometry. Only one of the following will satisfy the requirements for a degree: MATH 148, MATH 152 or MATH 172.

**Prerequisite:** MATH 147, MATH 151 or approval of instructor; also taught at Galveston campus.

## MATH 150 Functions, Trigonometry and Linear Systems

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

(MATH 2412) Functions, Trigonometry and Linear Systems. Graphs, functions, college algebra and trigonometry, linear systems and vectors; also taught at Galveston and Qatar campuses.

## MATH 151 Engineering Mathematics I

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

(MATH 2413) Engineering Mathematics I. Rectangular coordinates, vectors, analytic geometry, functions, limits, derivatives of functions, applications, integration, computer algebra. MATH 171 designed to be a more demanding version of this course. Only one of the following will satisfy the requirements for a degree: MATH 131, MATH 142, MATH 147, MATH 151 or MATH 171.

**Prerequisite:** Grade of C or better in MATH 150 or equivalent or acceptable score on TAMU Math Placement Exam; also taught at Galveston and Qatar campuses.

## MATH 152 Engineering Mathematics II

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

(MATH 2414) Engineering Mathematics II. Differentiation and integration techniques and their applications (area, volumes, work), improper integrals, approximate integration, analytic geometry, vectors, infinite series, power series, Taylor series, computer algebra. MATH 172 designed to be a more demanding version of this course. Only one of the following will satisfy the requirements for a degree: MATH 148, MATH 152 or MATH 172.

**Prerequisite:** Grade of C or better in MATH 151 or equivalent; also taught at Galveston and Qatar campuses.

## MATH 161 Engineering Mathematics II

**Credits 3. 3 Lecture Hours.**

Differentiation and integration techniques and their applications (area, volumes, work), improper integrals, approximate integration, analytic geometry, vectors, infinite series, power series, Taylor series. Only one of the following will satisfy the requirements for a degree: MATH 152, MATH 161 or MATH 172.

**Prerequisite:** MATH 151 or equivalent; Galveston campus.

## MATH 167 Explorations in Mathematics

**Credits 3. 3 Lecture Hours.**

Application of mathematics to topics of contemporary societal importance using quantitative methods; may include elements of management science (optimal routes, planning and scheduling), statistics (sampling/polling methods, analyzing data to make decisions), cryptography (codes used by stores, credit cards, internet security), fairness (apportionment, voting) patterns (symmetry, tessellations, fractals.), world health.

**Prerequisites:** High school algebra I and II.

## MATH 168 Finite Mathematics

**Credits 3. 3 Lecture Hours.**

Linear equations and applications; systems of linear equations, matrix algebra and applications, linear programming, probability and applications, statistics. Only one of the following will satisfy the requirements for a degree: MATH 140 or MATH 168.

**Prerequisites:** High school algebra I and II and geometry; also taught at Galveston campus.

## MATH 170 Freshman Mathematics Laboratory

**Credit 1. 2 Lab Hours.**

Computing and problem solving laboratory; introduction to the various mathematical disciplines; development of skills in mathematical problem solving and skills in teamwork. May be taken two times for credit.

**Prerequisites:** Concurrent enrollment in MATH 150, MATH 171, or MATH 172; admission to College of Science.

**MATH 171 Calculus I****Credits 4. 4 Lecture Hours.**

Vectors, functions, limits, derivatives, Mean Value Theorem, applications of derivatives, integrals, Fundamental Theorem of Calculus. Designed to be more demanding than MATH 151. Only one of the following will satisfy the requirements for a degree: MATH 131, MATH 142, MATH 147, MATH 151, or MATH 171.

**Prerequisite:** MATH 150 or equivalent or acceptable score on TAMU Math Placement Exam.

**MATH 172 Calculus II****Credits 4. 4 Lecture Hours.**

Techniques of integration, applications of integrals, improper integrals, sequences, infinite series, vector algebra and solid analytic geometry. Designed to be more demanding than MATH 152. Only one of the following will satisfy the requirements for a degree: MATH 148, MATH 152, or MATH 172.

**Prerequisite:** MATH 147, MATH 151 or MATH 171 or equivalent with a grade of C or better.

**MATH 200 Horizons of Mathematics****Credit 1. 1 Lecture Hour.**

Overview of different areas and topics of mathematics including logic, infinite sets, elements of topology, elements of history of mathematics; introduction to future courses in math degree plans and to some areas of research done by mathematics department faculty; topics may vary at the discretion of the instructor.

**Prerequisites:** MATH and APMS majors; freshmen or sophomore classification; approval of instructor.

**MATH 221 Several Variable Calculus****Credits 4. 4 Lecture Hours.**

Vector algebra and solid analytic geometry; calculus of functions of several variables; Lagrange multipliers; multiple integration, theory, methods and application; line and surface integrals, Green's and Stokes' theorems; Jacobians. Designed to be more demanding than MATH 251 and MATH 253. Only one of the following will satisfy the requirements for a degree: MATH 221, MATH 251, or MATH 253.

**Prerequisite:** Grade of C or better in MATH 148, MATH 152, or MATH 172, or equivalent.

**MATH 225 Advanced Spreadsheet Techniques****Credit 1. 1 Lecture Hour.**

Advanced commands, formatting and functionality of spreadsheets, with Excel being the particular example.

**Prerequisite:** MATH or APMS major.

**MATH 251 Engineering Mathematics III****Credits 3. 3 Lecture Hours.**

(MATH 2315) Engineering Mathematics III. Vector algebra, calculus of functions of several variables, partial derivatives, directional derivatives, gradient, multiple integration, line and surface integrals, Green's and Stokes' theorems. MATH 221 designed to be a more demanding version of this course. Only one of the following will satisfy the requirements for a degree: MATH 221, MATH 251, or MATH 253.

**Prerequisite:** MATH 148, MATH 152, or MATH 172; also taught at Galveston and Qatar campuses.

**MATH 253 Engineering Mathematics III****Credits 4. 3 Lecture Hours. 2 Lab Hours.**

(MATH 2415) Engineering Mathematics III. Vector algebra; calculus of functions of several variables, partial derivatives, directional derivatives, gradient, multiple integration, line and surface integrals, Green's and Stokes' theorems, computer algebra. MATH 221 designed to be a more demanding version of this course. Only one of the following will satisfy the requirements for a degree: MATH 221, MATH 251, or MATH 253.

**Prerequisite:** MATH 148, MATH 152, or MATH 172.

**MATH 281 Seminar in Mathematics****Credit 1. 1 Lecture Hour.**

Designed to familiarize students with mathematics pertaining to real world applications in such areas as biology, signal processing, quantum computation and robotics. May be taken four times for credit.

**MATH 285 Directed Studies****Credits 1 to 4. 1 to 4 Other Hours.**

Special problems not covered by any other lower-division course in the curriculum; intended for freshman and sophomore students.

**Prerequisite:** Approval of department head.

**MATH 289 Special Topics in...****Credits 1 to 4. 1 to 4 Lecture Hours.**

Selected topics in an identified area of mathematics. May be repeated for credit.

**Prerequisite:** Approval of instructor.

**MATH 291 Research****Credits 0 to 4. 0 to 4 Other Hours.**

Research conducted under the direction of faculty member in mathematics. May be repeated 2 times for credit.

**Prerequisites:** Freshman or sophomore classification and approval of instructor.

**MATH 300 Foundations of Mathematics****Credits 3. 3 Lecture Hours.**

Foundations of mathematics including logic, set theory, combinatorics, and number theory.

**Prerequisite:** Grade of C or better in MATH 148, MATH 152 or MATH 172, or equivalent.

**MATH 302 Discrete Mathematics****Credits 3. 3 Lecture Hours.**

Formal structures for describing data, algorithms and computing devices; theory and applications of sets, graphs and algebraic structures.

**Prerequisite:** MATH 148, MATH 152, or MATH 172.

**MATH 304 Linear Algebra****Credits 3. 3 Lecture Hours.**

Introductory course in linear algebra covering abstract ideas of vector space and linear transformation as well as models and applications of these concepts, such as systems of linear equations, matrices and determinants; MATH 323 designed to be a more demanding version of this course. Only one of the following will satisfy the requirements for a degree: MATH 304, MATH 307, MATH 309, MATH 311, or MATH 323.

**Prerequisite:** MATH 148, MATH 152, or MATH 172; junior or senior classification; also taught at Galveston campus.

**MATH 307 Mathematical Methods for Material Scientists and Engineers**  
**Credits 3. 3 Lecture Hours.**

Elementary ordinary differential equations and their solutions; series solutions of ordinary differential equations; linear algebra concepts covering systems of linear equations, matrices, determinants and eigenvalue problems; applications of the above topics in materials sciences and engineering. Only one of the following will satisfy the requirements for a degree: MATH 307 or MATH 308; MATH 304, MATH 307, MATH 309, MATH 311, or MATH 323.

**Prerequisite:** MATH 221, MATH 251, or MATH 253, or concurrent enrollment.

**MATH 308 Differential Equations**  
**Credits 3. 3 Lecture Hours.**

Ordinary differential equations, solutions in series, solutions using Laplace transforms, systems of differential equations. Only one of the following will satisfy the requirements for a degree: MATH 307 or MATH 308.

**Prerequisite:** MATH 221, MATH 251, or MATH 253, or concurrent enrollment; knowledge of computer algebra system; also taught at Galveston and Qatar campuses.

**MATH 309 Linear Algebra for Differential Equations**  
**Credits 3. 3 Lecture Hours.**

Systems of linear equations, matrices, determinants, vector spaces, linear transformations, eigenvalues and eigenvectors, diagonalization, inner product spaces, orthogonal functions, separation of variables, Fourier series, Bessel functions. Only one of the following will satisfy the requirements for a degree: MATH 304, MATH 307, MATH 309, MATH 311, or MATH 323.

**Prerequisites:** MATH 221, MATH 251, or MATH 253; MATH 308 or concurrent enrollment; junior or senior classification or approval of instructor.

**MATH 311 Topics in Applied Mathematics I**  
**Credits 3. 3 Lecture Hours.**

Systems of linear equations, matrices, determinants, vector spaces, linear transformations, eigenvalues and eigenvectors, diagonalization, inner product spaces, orthogonal functions; vector analysis, including gradient, divergence, curl, line and surface integrals, Gauss', Green's and Stokes' theorems. Only one of the following will satisfy the requirements for a degree: MATH 304, MATH 307, MATH 309, MATH 311, or MATH 323.

**Prerequisites:** MATH 221, MATH 251, or MATH 253; MATH 308 or concurrent enrollment; junior or senior classification or approval of instructor; also taught at Galveston and Qatar campuses.

**MATH 323 Linear Algebra**  
**Credits 3. 3 Lecture Hours.**

Linear equations and matrices; real vector spaces, linear transformations, change of bases, determinants, eigenvalues and eigenvectors, diagonalization, inner products; designed to include more theory and be more demanding than MATH 304. Only one of the following will satisfy the requirements for a degree: MATH 304, MATH 307, MATH 309, MATH 311, or MATH 323.

**Prerequisites:** MATH 148, MATH 152 or MATH 172; MATH 300; junior or senior classification or approval of instructor.

**MATH 325 The Mathematics of Interest**  
**Credits 3. 3 Lecture Hours.**

The mathematical theory associated with interest; annuities; varying annuities; sinking funds and amortization; coupon bonds; valuation of noncallable bonds; yield to maturity; yield curve; spot rates and forward rates; internal rate of return; duration and convexity; portfolio immunization.

**Prerequisite:** MATH 152 or MATH 172.

**MATH 365 Structure of Mathematics I**  
**Credits 3. 3 Lecture Hours.**

Informal logic, sets, relations, functions, whole numbers, numeration systems, binary operations, integers, elementary number theory, modular systems, rational numbers and the system of real numbers. Designed primarily for elementary teacher certification. Others must have consent of instructor.

**Prerequisites:** Must have completed University Core Curriculum mathematics requirements with a grade of C or better.

**MATH 366 Structure of Mathematics II**  
**Credits 3. 3 Lecture Hours.**

Geometry, measurement and coordinate geometry. Designed primarily for elementary teacher certification. Others must have consent of instructor.

**Prerequisite:** MATH 365 or equivalent with a grade of C or better.

**MATH 367 Basic Concepts of Geometry**  
**Credits 3. 3 Lecture Hours.**

Formal development of geometry: finite [Euclidean and non-Euclidean]. Designed primarily for elementary mathematics teacher certification. Others must have consent of instructor.

**Prerequisite:** MATH 366 or equivalent with a grade of C or better.

**MATH 375 Intermediate Real Analysis**  
**Credits 3. 3 Lecture Hours.**

Development of the real numbers, limits, foundations and major theorems of calculus. Designed primarily for mathematics teacher certification. Others must have consent of instructor.

**Prerequisite:** MATH 300 or equivalent.

**MATH 376 Intermediate Abstract Algebra**  
**Credits 3. 3 Lecture Hours.**

Relations, functions, binary operators, rings, homomorphisms, integral domains and fields. Designed primarily for mathematics teacher certification. Others must have consent of instructor.

**Prerequisites:** MATH 300 or MATH 302; MATH 304 or equivalent.

**MATH 396 Communications in Mathematics**  
**Credit 1. 1 Lecture Hour.**

Electronic, written, and oral communications in mathematics.

**Prerequisites:** MATH 300, junior or senior classification, and mathematics major.

**MATH 401 Advanced Engineering Mathematics**  
**Credits 3. 3 Lecture Hours.**

Engineering mathematics including Perturbation Theory, Fourier series and partial differential equations. Designed primarily for engineering majors. Others must have consent of instructor.

**Prerequisite:** MATH 308; also taught at Galveston campus.

**MATH 403 Mathematics and Technology**  
**Credits 3. 3 Lecture Hours.**

Mathematical problem-solving and communication through the use of various technologies (both hardware and software). Intended primarily, but not limited to, students working toward teacher certification.

**Prerequisite:** MATH 367 or MATH 467 with a grade of C or better.

**MATH 407 Complex Variables**  
**Credits 3. 3 Lecture Hours.**

Fundamental theory of analytic functions, including residues and their applications.

**Prerequisite:** MATH 221, MATH 251, or MATH 253.

**MATH 409 Advanced Calculus I****Credits 3. 3 Lecture Hours.**

Axioms of the real number system; point set theory of  $\mathbb{R}^1$ ; compactness, completeness and connectedness; continuity and uniform continuity; sequences, series; theory of Riemann integration.

**Prerequisites:** MATH 300; MATH 221, MATH 251 or MATH 253.**MATH 410 Advanced Calculus II****Credits 3. 3 Lecture Hours.**

Differential and integral calculus of functions defined on  $\mathbb{R}^m$  including inverse and implicit function theorems and change of variable formulas for integration; uniform convergence.

**Prerequisites:** MATH 304 or MATH 323; MATH 409.**MATH 411 Mathematical Probability****Credits 3. 3 Lecture Hours.**

Probability spaces, discrete and continuous random variables, special distributions, joint distributions, expectations, law of large numbers, the central limit theorem.

**Prerequisite:** MATH 221, MATH 251, or MATH 253.**MATH 412 Theory of Partial Differential Equations****Credits 3. 3 Lecture Hours.**

Formulation and solution of partial differential equations of mathematical physics; Fourier series and transform methods, complex variable methods, methods of characteristics and first order equations.

**Prerequisite:** MATH 308 or approval of instructor.**MATH 414 Fourier Series and Wavelets****Credits 3. 3 Lecture Hours.**

Fourier series and wavelets with applications to data compression and signal processing.

**Prerequisite:** MATH 304, MATH 309, MATH 311, or MATH 323; also taught at Qatar campus.**MATH 415 Modern Algebra I****Credits 3. 3 Lecture Hours.**

A study of groups, rings, fields with emphasis on the theoretical aspects and proofs.

**Prerequisite:** MATH 300; MATH 304, MATH 309, MATH 311, or MATH 323.**MATH 416 Modern Algebra II****Credits 3. 3 Lecture Hours.**

Continuation of topics introduced in MATH 415 including Galois Theory and the Sylow Theorems with emphasis on the theoretical aspects.

**Prerequisite:** MATH 415; junior or senior classification.**MATH 417 Numerical Methods****Credits 4. 3 Lecture Hours. 3 Lab Hours.**

Numerical methods for applications; qualitative discussion of convergence and stability properties; computer implementation; interpolation and quadrature, initial value problems, matrix decompositions, interactive solution of linear and non-linear systems, least squares approximation, boundary value problems for ordinary differential equations.

**Prerequisites:** MATH 304, MATH 309, MATH 311, or MATH 323; MATH 308; ability to program; junior or senior classification.**MATH 419 Applications of Actuarial Science****Credits 2. 2 Lecture Hours.**

Applications of actuarial science using mathematical and statistical methods to assess risk in the insurance and finance industries; emphasis on probability, statistics, finance and economics; focus on using probabilistic models in the estimation of insurance premiums.

**Prerequisite:** MATH 411 or STAT 414 or approval of math advisor.**MATH 420 Application of Actuarial Science II****Credits 2. 2 Lecture Hours.**

Use of mathematical and statistical methods to price various financial instruments, such as bonds; understanding how the term structure of interest rates affect the price of these instruments.

**Prerequisite:** MATH 325 or concurrent enrollment, or approval of instructor.**MATH 423 Linear Algebra II****Credits 3. 3 Lecture Hours.**

Eigenvalues, similarity and canonical forms, advanced topics to be chosen by the instructor.

**Prerequisites:** MATH 300 or CSCE 222/ECEN 222; MATH 304 or MATH 323, or approval of instructor.**MATH 424/STAT 424 Probability and Computing****Credits 3. 3 Lecture Hours.**

Applications of modern probability in data science, with an emphasis on randomization and the role of probabilistic techniques in computing; discrete random variables and expectation; deviation inequalities and applications to randomized algorithms; probabilistic methods and satisfiability; Monte Carlo method; sample complexity; combinatorial dimension.

**Prerequisites:** MATH 304, MATH 309, MATH 311, or MATH 323; MATH 411 or STAT 414.**Cross Listing:** STAT 424/MATH 424.**MATH 425 The Mathematics of Contingent Claims****Credits 3. 3 Lecture Hours.**

The mathematical theory associated with asset price dynamics; binomial pricing models; Black-Scholes analysis; hedging; volatility smile; implied volatility trees; implied binomial trees.

**Prerequisites:** MATH 308; MATH 411, STAT 211 or STAT 414.**MATH 427 Introduction to Number Theory****Credits 3. 3 Lecture Hours.**

Prime and composite integers; Euclidean algorithm; modular arithmetic; Chinese remainder theorem; unique factorization; quadratic reciprocity; Riemann zeta function; representation of numbers as a sum of squares.

**Prerequisites:** MATH 300; MATH 304 or MATH 323.**MATH 431 Structures and Methods of Combinatorics****Credits 3. 3 Lecture Hours.**

Enumerative techniques generating functions, partially ordered sets, elementary graph theory, elementary Ramsey theory.

**Prerequisite:** MATH 300 or MATH 302 or approval of instructor.**MATH 433 Applied Algebra****Credits 3. 3 Lecture Hours.**

An introduction to groups, rings, fields with emphasis on modular arithmetic; applications to number theory, coding theory, and other areas.

**Prerequisites:** MATH 300 or MATH 302; MATH 304 or MATH 323.**MATH 436 Introduction to Topology****Credits 3. 3 Lecture Hours.**

Metric spaces; continuity of metric spaces; topological spaces; basic notions; separation axioms; compactness; local compactness; connectedness; basic notions in homotopy theory; quotient spaces, paracompactness and topological manifolds.

**Prerequisite:** MATH 409.

**MATH 437 Principles of Numerical Analysis****Credits 4. 3 Lecture Hours. 3 Lab Hours.**

Mathematical principles of numerical analysis and their application to the study of particular methods; fixed-point iteration, Newton's method; normed vector spaces and operators, Schur decomposition, convergent matrices, minimization methods, conjugate gradient method; polynomial interpolation of Lagrange and Hermite; best approximation, Bernstein and Weierstrass Theorems, numerical quadrature.

**Prerequisites:** MATH 304, MATH 309, MATH 311, or MATH 323; MATH 308; MATH 409; ability to program; junior or senior classification.

**MATH 439 Differential Geometry of Curves and Surfaces****Credits 3. 3 Lecture Hours.**

Local and global theory of parameterized curves; regular surfaces, local coordinates, first fundamental form, orientation, area; Gauss map, second fundamental form; Gauss Bonnet theorem; additional topics to be selected by the instructor.

**Prerequisites:** MATH 308; MATH 304 or MATH 323.

**MATH 442 Mathematical Modeling****Credits 3. 3 Lecture Hours.**

The construction of mathematical models from areas such as economics, game theory, integer programming, mathematical biology and mathematical physics.

**Prerequisites:** MATH 304, MATH 309, MATH 311, or MATH 323; MATH 308 or equivalent.

**MATH 446 Principles of Analysis I****Credits 3. 3 Lecture Hours.**

Construction of the real and complex numbers; topology of metric spaces, compactness and connectedness; Cauchy sequences, completeness and the Baire Category Theorem; Continuous Mappings; introduction to Point-Set Topology.

**Prerequisites:** MATH 409; junior or senior classification.

**MATH 447 Principles of Analysis II****Credits 3. 3 Lecture Hours.**

Riemann-Stieltjes integration; sequences and series of functions; the Stone-Weierstrass and Arzela-Ascoli Theorems; introduction to Lebesgue measure theory and integration.

**Prerequisites:** MATH 446 or approval of instructor; junior or senior classification.

**MATH 460 Tensors and General Relativity****Credits 3. 3 Lecture Hours.**

Vectors and tensors in special relativity, curvature, manifolds, covariant differentiation, Einstein field equations, Schwarzschild geometry and black holes, cosmology, gauge field theories.

**Prerequisites:** MATH 308; PHYS 331 or MATH 323 or MATH 311; junior or senior classification.

**MATH 467 Modern Geometry****Credits 3. 3 Lecture Hours.**

Modern development of Euclidean geometry (Hilbert axioms) with historical and philosophical context; independence of the parallel postulate; models of hyperbolic non-Euclidean geometry.

**Prerequisite:** Grade of C or better in MATH 304, MATH 309, MATH 311, MATH 300 or MATH 323.

**MATH 469 Introduction to Mathematical Biology****Credits 3. 3 Lecture Hours.**

Introduction to mathematical modeling techniques in the biological sciences; continuous versus discrete models; deterministic versus stochastic models; includes population dynamics and ecology, spread of infectious diseases, population genetics and evolution, spatial pattern formation.

**Prerequisites:** MATH 304 or MATH 323; MATH 308 or equivalent.

**MATH 470 Communications and Cryptography****Credits 3. 3 Lecture Hours.**

Introduction to coded communications, digital signatures, secret sharing, one-way functions, authentication, error control and data compression.

**Prerequisites:** MATH 304 or MATH 309 or MATH 311 or MATH 323; CSCE 110 or CSCE 111 or CSCE 121 or CSCE 206 or ENGR 112; approval of instructor.

**MATH 471 Communications and Cryptography II****Credits 3. 3 Lecture Hours.**

Additional topics in coded communications; information and entropy, elliptical curves, error corrections, quantum methods.

**Prerequisites:** MATH 470 or consent of instructor.

**MATH 472 Elliptic Curve Cryptography****Credits 3. 3 Lecture Hours.**

Theory of the group law on elliptic curves with applications to problems in cryptography; elliptic curves over finite fields, rational numbers, real and complex numbers; elliptic curve based cryptosystems, digital signatures, and factorization methods.

**Prerequisites:** MATH 415 or MATH 433.

**MATH 478 Topological Data Analysis****Credits 3. 3 Lecture Hours.**

Topological Data Analysis with a view toward persistent homology of point clouds for applications to data analysis; homology of simplicial complexes over a field; functorial clustering methods; persistent homology; real-world applications to data analysis.

**Prerequisites:** MATH 304, MATH 309, MATH 311, or MATH 323.

**MATH 482 Research Seminar****Credits 3. 3 Lecture Hours.**

Problems, methods and recent developments in mathematics, with emphasis on projects, and written and oral presentations. May be repeated for credit.

**Prerequisites:** MATH 409 or MATH 415 (may be taken concurrently); junior or senior classification; approval of instructor.

**MATH 485 Directed Studies****Credits 1 to 8. 1 to 8 Other Hours.**

Special problems in mathematics not covered by any other course in the curriculum. Work may be in either theory or laboratory.

**Prerequisite:** Approval of department head; also taught at Galveston campus.

**MATH 489 Special Topics in...****Credits 1 to 4. 1 to 4 Lecture Hours.**

Selected topics in an identified area of mathematics. May be repeated for credit.

**Prerequisite:** Approval of instructor; also taught at Galveston campus.

**MATH 490 The Putnam Challenge****Credit 1. 1 Lecture Hour.**

Intensive individualized training for preparation for the Putnam Exam, a national contest for mathematics majors. May be taken four times for credit.

**Prerequisites:** Approval of instructor; junior or senior classification.

**MATH 491 Research**

**Credits 0 to 3. 0 to 3 Other Hours.**

Active research of basic nature under supervision of Department of Mathematics or affiliated department graduate faculty member; a maximum of 6 hours of credit can be used in degree plans. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.

**Prerequisites:** Mathematics or applied mathematical sciences major or minor; junior or senior classification or approval of mathematics advisor; also taught at Galveston campus.