

MATHEMATICS (MAT)

College of Letters & Science

MAT 000B – Elementary Algebra (no credit) (0 units)

Course Description: Basic concepts of algebra, including polynomials, factoring, equations, graphs, and inequalities. Offered only if sufficient number of students enroll.

Learning Activities: Lecture 3 hour(s).

Enrollment Restriction(s): Not open to concurrent student enrollment.

Grade Mode: Pass/No Pass only.

MAT 000C – Trigonometry (no credit) (0 units)

Course Description: Basic concepts of trigonometry, including trigonometric functions, identities, inverse functions, and applications. Offered only if sufficient number of students enroll.

Learning Activities: Lecture 2 hour(s).

Enrollment Restriction(s): Not open to concurrent student enrollment.

Grade Mode: Pass/No Pass only.

MAT 000D – Intermediate Algebra (no credit) (0 units)

Course Description: Basic concepts of algebra, prepares student for college work in mathematics, such as MAT 016A or MAT 021A. Functions, equations, graphs, logarithms, and systems of equations. Offered only if sufficient number of students enroll.

Learning Activities: Lecture 3 hour(s).

Enrollment Restriction(s): Not open to concurrent student enrollment.

Grade Mode: Pass/No Pass only.

MAT 012 – Precalculus (3 units)

Course Description: Topics selected for their use in calculus, including functions and their graphs, slope, zeroes of polynomials, exponential, logarithmic and trigonometric functions, sketching surfaces and solids.

Prerequisite(s): Two years of high school algebra, plane geometry, plane trigonometry; and obtaining required score on the Precalculus Diagnostic Examination.

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have completed any of MAT 016A, MAT 016B, MAT 016C, MAT 017A, MAT 017B, MAT 017C, MAT 021A, MAT 021B, or MAT 021C with a C- or better.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 016A – Short Calculus (3 units)

Course Description: Limits; differentiation of algebraic functions; analytic geometry; applications, in particular to maxima and minima problems.

Prerequisite(s): Two years of high school algebra, plane geometry, plane trigonometry, and satisfying the Mathematics Placement Requirement.

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 017B, MAT 017C, MAT 021A, MAT 021B, or MAT 021C; only 2 units of credit to students who have completed MAT 017A.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 016B – Short Calculus (3 units)

Course Description: Integration; calculus for trigonometric, exponential, and logarithmic functions; applications.

Prerequisite(s): MAT 016A C- or better or MAT 017A C- or better or MAT 021A C- or better or MAT 021AH C- or better.

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 017C, MAT 021B, or MAT 021C; only 2 units of credit to students who have completed MAT 017B.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 016C – Short Calculus (3 units)

Course Description: Differential equations; partial derivatives; double integrals; applications; series.

Prerequisite(s): MAT 016B C- or better or MAT 017B C- or better or MAT 021B C- or better or MAT 021BH C- or better.

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 021C; only 2 units of credit to students who have completed MAT 017C.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 017A – Calculus for Biology & Medicine (4 units)

Course Description: Introduction to differential calculus via applications in biology and medicine. Limits, derivatives of polynomials, trigonometric, and exponential functions, graphing, applications of the derivative to biology and medicine.

Prerequisite(s): Two years of high school algebra, plane geometry, plane trigonometry, and analytical geometry, and satisfying the Mathematics Placement Requirement.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 016B, MAT 016C, MAT 021A, MAT 021B, or MAT 021C; only 2 units of credit to students who have completed MAT 016A.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 017B – Calculus for Biology & Medicine (4 units)

Course Description: Introduction to integral calculus and elementary differential equations via applications to biology and medicine.

Fundamental theorem of calculus, techniques of integration including integral tables and numerical methods, improper integrals, elementary first order differential equations, applications in biology and medicine.

Prerequisite(s): MAT 016A C- or better or MAT 017A C- or better or MAT 021A C- or better or MAT 021AH C- or better.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 016C, MAT 021B, or MAT 021C; only 2 units of credit for students who have completed MAT 016B.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 017C – Calculus for Biology & Medicine (4 units)

Course Description: Matrix algebra, functions of several variables, partial derivatives, systems of differential equations, and applications to biology and medicine.

Prerequisite(s): MAT 017B C- or better.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 021C; only 2 units of credit to students who have completed MAT 016C.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Scientific Literacy (SL).

MAT 019A – Calculus for Data-Driven Applications (4 units)

Course Description: Calculus and other mathematical methods necessary in data driven analysis in the sciences, technology and the humanities.

Prerequisite(s): Two years of high school algebra, plane geometry, plane trigonometry, and satisfying the Mathematics Placement Requirement.

Learning Activities: Lecture 3 hour(s), Laboratory 2 hour(s)

Credit Limitation(s): Not open for credit to students who have completed MAT 016A, MAT 016B, MAT 016C, MAT 017B, MAT 017C, MAT 021A, MAT 021B, or MAT 021C; only 2 units of credit to students who have completed MAT 017A.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 019B – Calculus for Data-Driven Applications (4 units)

Course Description: Calculus and other mathematical methods necessary in data driven analysis in the sciences, technology, and the humanities.

Prerequisite(s): MAT 017A C- or better or MAT 021A C- or better or MAT 021AH C- or better or MAT 019A C- or better.

Learning Activities: Lecture 3 hour(s); Laboratory 2 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 016B, 016C, MAT 017C, MAT 021B, or MAT 021C; only 2 units of credit to students who have completed MAT 017B.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 019C – Calculus for Data-Driven Applications (4 units)

Course Description: Calculus and other mathematical methods necessary in data-driven analysis in the sciences, technology and the humanities.

Multivariable calculus, differential equations, partial derivatives.

Prerequisite(s): MAT 019B C- or better or MAT 017B C- or better or MAT 021B C- or better or MAT 021BH C- or better.

Learning Activities: Lecture 3 hour(s); Laboratory 2 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 016C or MAT 021C; only 2 units of credit to students who have completed MAT 017C.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 021A – Calculus (4 units)

Course Description: Functions, limits, continuity. Slope and derivative. Differentiation of algebraic and transcendental functions. Applications to motion, natural growth, graphing, extrema of a function. Differentials. L'Hopital's rule.

Prerequisite(s): Two years of high school algebra, plane geometry, plane trigonometry, and analytical geometry, and satisfying the Mathematics Placement Requirement.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 016B, MAT 016C, MAT 017B, or MAT 017C; only 2 units of credit to students who have completed MAT 016A or MAT 017A.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 021AH – Honors Calculus (4 units)

Course Description: More intensive treatment of material covered in MAT 021A.

Prerequisite(s): A Precalculus Diagnostic Examination score significantly higher than the minimum for MAT 021A is required.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 021AL – Emerging Scholars Program Calculus Workshop (2 units)

Course Description: Functions, limits, continuity. Slope and derivative. Same course content as MAT 021A. Enrollment for students in the Emerging Scholars Program by instructor's invitation only.

Prerequisite(s): MAT 021A required concurrently.

Learning Activities: Workshop 6 hour(s).

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE).

MAT 021B – Calculus (4 units)

Course Description: Continuation of MAT 021A. Definition of definite integral, fundamental theorem of calculus, techniques of integration.

Application to area, volume, arc length, average of a function, improper integral, surface of revolution. May be taught abroad.

Prerequisite(s): (MAT 021A C- or better or MAT 021AH C- or better) or MAT 017A B or better.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Credit Limitation(s): Only 2 units of credit to students who have completed MAT 016B, MAT 016C, MAT 017B, or MAT 017C.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 021BH – Honors Calculus (4 units)

Course Description: More intensive treatment of material covered in MAT 021B. Students completing MAT 021BH can continue with MAT 021CH or the regular MAT 021C.

Prerequisite(s): MAT 021A B or better or MAT 021AH B or better.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 021BL – Emerging Scholars Program Calculus Workshop (2 units)

Course Description: Continuation of MAT 021A. Same course content as MAT 021B. Enrollment for students in the Emerging Scholars Program by instructor's invitation only.

Prerequisite(s): MAT 021B required concurrently.

Learning Activities: Workshop 6 hour(s).

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE).

MAT 021C – Calculus (4 units)

Course Description: Continuation of MAT 021B. Sequences, series, tests for convergence, Taylor expansions. Vector algebra, vector calculus, scalar and vector fields. Partial derivatives, total differentials. Applications to maximum and minimum problems in two or more variables. Applications to physical systems.

Prerequisite(s): MAT 016C C- or better or MAT 017C C- or better or MAT 021B C- or better or MAT 021BH C- or better or MAT 017B B or better.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 021CH – Honors Calculus (4 units)

Course Description: More intensive treatment of material covered in MAT 021C.

Prerequisite(s): MAT 021B B or better or MAT 021BH B or better.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 021CL – Emerging Scholars Program Calculus Workshop (2 units)

Course Description: Continuation of MAT 021B. Same course content as MAT 021C. Enrollment for students in the Emerging Scholars Program by instructor's invitation only.

Prerequisite(s): MAT 021C required concurrently.

Learning Activities: Workshop 6 hour(s).

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE).

MAT 021D – Vector Analysis (4 units)

Course Description: Continuation of MAT 021C. Definite integrals over plane and solid regions in various coordinate systems. Line and surface integrals. Green's theorem, Stoke's theorem, divergence theorem.

Prerequisite(s): (MAT 021C C- or better or MAT 021CH C- or better) or MAT 017C B or better.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 021M – Accelerated Calculus (5 units)

Course Description: Accelerated treatment of material from MAT 021A and MAT 021B, with detailed presentation of theory, definitions, and proofs, and treatment of computational aspects of calculus at a condensed but sophisticated level.

Prerequisite(s): Grade of B or higher in both semesters of high school calculus or a score of 4 or higher on the Advanced Placement Calculus AB exam, and obtaining the required score on the Precalculus Diagnostic Examination and its trigonometric component.

Learning Activities: Lecture/Discussion 4 hour(s), Discussion/Laboratory 1 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 021A or MAT 021B.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 022A – Linear Algebra (3 units)

Course Description: Matrices and linear transformations, determinants, eigenvalues, eigenvectors, diagonalization, factorization.

Prerequisite(s): (MAT 016C C- or better or MAT 017C C- or better or MAT 021C C- or better or MAT 021CH C- or better); (ENG 006 or EME 005 or ECH 060 or MAT 022AL (can be concurrent)).

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have completed MAT 067.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 022AL – Linear Algebra Computer Laboratory (1 unit)

Course Description: Introduction to MATLAB and its use in linear algebra.

Prerequisite(s): MAT 016C or MAT 017C or MAT 021C or MAT 021CH.

Learning Activities: Laboratory 3 hour(s).

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 022B – Differential Equations (3 units)

Course Description: Solutions of elementary differential equations.

Prerequisite(s): (MAT 022A C- or better or MAT 067 C- or better).

Learning Activities: Lecture 3 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 027A – Linear Algebra with Applications to Biology (4 units)

Course Description: Introduction to linear algebra with biological, medical, and bioengineering applications. Matrix algebra, vector spaces, orthogonality, determinants, eigenvalues, eigenvectors, principal component analysis, singular value decomposition, and linear transformations. Computer labs cover mathematical and computational techniques for modeling biological systems.

Prerequisite(s): MAT 017C C- or better or MAT 021C C- or better or MAT 021CH C- or better.

Learning Activities: Lecture 3 hour(s), Laboratory 2 hour(s).

Credit Limitation(s): Only 1 unit of credit for students who have completed MAT 022A.

Cross Listing: BIS 027A.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 027B – Differential Equations with Applications to Biology (4 units)

Course Description: Solutions of differential equations with biological, medical, and bioengineering applications. First and second order linear equations, phase plane analysis, nonlinear dynamics, Laplace transforms, and the diffusion equation. Computer labs cover mathematical and numerical techniques for modeling biological systems.

Prerequisite(s): (MAT 027A C- or better or BIS 027A C- or better) or (MAT 022A C- or better, (MAT 022AL C- or better or ENG 006 C- or better or ECS 032A C- or better or ECS 036A C- or better or ECH 060 C- or better or EME 005 C- or better)).

Learning Activities: Lecture 3 hour(s), Laboratory 2 hour(s).

Credit Limitation(s): Only 1 unit of credit for students who have completed MAT 022B.

Cross Listing: BIS 027B.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 036 – Fundamentals of Mathematics (3 units)

Course Description: Introduction to fundamental mathematical ideas selected from the principal areas of modern mathematics. Properties of the primes, the fundamental theorems of arithmetic, properties of the rationals and irrationals, binary and other number systems.

Prerequisite(s): Satisfaction of the Mathematics Placement Requirement.

Learning Activities: Lecture 3 hour(s).

Credit Limitation(s): Not open for credit to students who have taken MAT 108.

Grade Mode: Letter.

MAT 067 – Modern Linear Algebra (4 units)

Course Description: Rigorous treatment of linear algebra; topics include vector spaces, bases and dimensions, orthogonal projections, eigenvalues and eigenvectors, similarity transformations, singular value decomposition and positive definiteness.

Prerequisite(s): MAT 021C C- or better or MAT 021CH C- or better.

Learning Activities: Lecture/Discussion 4 hour(s).

Credit Limitation(s): Only 1 unit of credit to students who have completed MAT 022A.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 071A – Explorations in Elementary Mathematics (3 units)

Course Description: Weekly explorations of mathematical ideas related to the elementary school curriculum will be carried out by cooperative learning groups. Lectures will provide background and synthesize the results of group exploration.

Prerequisite(s): Two years of high school mathematics.

Learning Activities: Lecture 2 hour(s), Laboratory 3 hour(s).

Grade Mode: Letter.

MAT 071B – Explorations in Elementary Mathematics (3 units)

Course Description: Weekly explorations of mathematical ideas related to the elementary school curriculum will be carried out by cooperative learning groups. Lectures will provide background and synthesize the results of group exploration.

Prerequisite(s): Two years of high school mathematics.

Learning Activities: Lecture 2 hour(s), Laboratory 3 hour(s).

Grade Mode: Letter.

MAT 089 – Elementary Problem Solving (1 unit)

Course Description: Solve and present solutions to challenging and interesting problems in elementary mathematics.

Prerequisite(s): High school mathematics through precalculus.

Learning Activities: Lecture 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Pass/No Pass only.

MAT 098 – Directed Group Study (1-5 units)

Course Description: Directed group study.

Prerequisite(s): Consent of instructor.

Learning Activities: Variable.

Grade Mode: Pass/No Pass only.

MAT 099 – Special Study for Undergraduates (1-5 units)

Course Description: Special study for undergraduates.

Prerequisite(s): Consent of instructor.

Learning Activities: Variable.

Grade Mode: Pass/No Pass only.

MAT 107 – Probability & Stochastic Processes with Applications to Biology (4 units)

Course Description: Introduction to probability theory and stochastic processes with biological, medical, and bioengineering applications. Combinatorics, discrete and continuous random variables, Bayes' formula, conditional probability, Markov chains, Poisson processes, and Brownian motion. Computer labs cover mathematical and computational modeling techniques.

Prerequisite(s): (MAT 027A C- or better or BIS 027A C- or better) or (MAT 022A C- or better, (MAT 022AL C- or better or ENG 006 C- or better or ECS 032A C- or better or ECS 036A C- or better or ECH 060 C- or better or EME 005 C- or better)).

Learning Activities: Lecture 3 hour(s), Laboratory 2 hour(s).

Credit Limitation(s): Only 2 units of credit for students who have completed MAT 135A or STA 131A.

Cross Listing: BIS 107.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 108 – Introduction to Abstract Mathematics (4 units)

Course Description: Rigorous treatment of mathematical concepts with emphasis on developing the ability to understand abstract mathematical ideas, to read and write mathematical concepts, and to prove theorems. Designed to serve as preparation for the more rigorous upper division courses.

Prerequisite(s): MAT 021B.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 111 – History of Mathematics (4 units)

Course Description: History of mathematics from ancient times through the development of calculus. Mathematics from Arab, Hindu, Chinese and other cultures. Selected topics from the history of modern mathematics.

Prerequisite(s): MAT 127A or MAT 067 or MAT 108 or MAT 114 or MAT 115A or MAT 141 or MAT 145; 8 units of upper division Mathematics.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 114 – Convex Geometry (4 units)

Course Description: Topics selected from the theory of convex bodies, convex functions, geometric inequalities, combinatorial geometry, and integral geometry. Designed to serve as preparation for the more rigorous upper division courses.

Prerequisite(s): MAT 021C; (MAT 022A or BIS 027A or MAT 067).

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 115A – Number Theory (4 units)

Course Description: Divisibility and related topics, diophantine equations, selected topics from the theory of prime numbers. Designed to serve as preparation for the more rigorous upper division courses.

Prerequisite(s): MAT 021B.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 115B – Number Theory (4 units)

Course Description: Euler function, Moebius function, congruences, primitive roots, quadratic reciprocity law.

Prerequisite(s): MAT 115A; (MAT 022A or MAT 027A or MAT 067 or BIS 027A).

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 116 – Differential Geometry (4 units)

Course Description: Vector analysis, curves, and surfaces in three dimensions.

Prerequisite(s): MAT 021D; (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B).

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 118A – Partial Differential Equations: Elementary Methods (4 units)

Course Description: Derivation of partial differential equations; separation of variables; equilibrium solutions and Laplace's equation; Fourier series; method of characteristics for the one dimensional wave equation.

Solution of nonhomogeneous equations.

Prerequisite(s): MAT 021D; (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B).

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Enrollment Restriction(s): Pass One open to Applied Mathematics, Mathematics, Mathematics & Scientific Computation, Mathematical Analytics & Operations Research.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 118B – Partial Differential Equations: Eigenfunction Expansions (4 units)

Course Description: Sturm-Liouville Theory; selfadjoint operators; mixed boundary conditions; partial differential equations in two and three dimensions; Eigenvalue problems in circular domains; nonhomogeneous problems and the method of eigenfunction expansions; Poisson's Equations.

Prerequisite(s): MAT 118A.

Learning Activities: Lecture 3 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 118C – Partial Differential Equations: Green's Functions & Transforms (4 units)

Course Description: Green's functions for one-dimensional problems and Poisson's equation; Fourier transforms; Green's Functions for time dependent problems; Laplace transform and solution of partial differential equations.

Prerequisite(s): MAT 118B.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 119A – Ordinary Differential Equations (4 units)

Course Description: Scalar and planar autonomous systems; nonlinear systems and linearization; existence and uniqueness of solutions; matrix solution of linear systems; phase plane analysis; stability analysis; bifurcation theory; Liapunov's method; limit cycles; Poincare Bendixon theory.

Prerequisite(s): MAT 021D; (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B).

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 119B – Ordinary Differential Equations (4 units)

Course Description: Lorentz equations; Poincare maps; center manifolds and normal forms; scalar and planar maps; phase space analysis for iterated maps; period-doubling bifurcation; Lyapunov exponent; chaos and symbolic dynamics; strange attractors; fractals.

Prerequisite(s): MAT 119A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 124 – Mathematical Biology (4 units)

Course Description: Methods of mathematical modeling of biological systems including difference equations, ordinary differential equations, stochastic and dynamic programming models. Computer simulation methods applied to biological systems. Applications to population growth, cell biology, physiology, evolutionary ecology and protein clustering. MATLAB programming required.

Prerequisite(s): (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B).

Learning Activities: Lecture 3 hour(s), Project.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 127A – Real Analysis (4 units)

Course Description: Real numbers, sequences, series, and continuous functions.

Prerequisite(s): (MAT 021C or MAT 021CH); (MAT 067 or (MAT 022A or MAT 027A or BIS 027A), MAT 108).

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

MAT 127B – Real Analysis (4 units)

Course Description: Derivatives, integrals, sequences of functions, and power series.

Prerequisite(s): MAT 127A.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

MAT 127C – Real Analysis (4 units)

Course Description: Metric spaces and multi-variable calculus.

Prerequisite(s): MAT 127B.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

MAT 128A – Numerical Analysis (4 units)

Course Description: Error analysis, approximation, interpolation, numerical differentiation and integration. Programming in language such as Pascal, Fortran, or BASIC required.

Prerequisite(s): MAT 021C; (ECS 032A or ENG 006 or EME 005 or ECS 030).

Learning Activities: Lecture 3 hour(s), Project.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 128B – Numerical Analysis in Solution of Equations (4 units)

Course Description: Solution of nonlinear equations and nonlinear systems. Minimization of functions of several variables. Simultaneous linear equations. Eigenvalue problems. Linear programming. Programming in language such as Pascal, Fortran, or BASIC required.

Prerequisite(s): (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (ECS 032A or ENG 006 or EME 005 or ECS 030).

Learning Activities: Lecture 3 hour(s), Project.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 128C – Numerical Analysis in Differential Equations (4 units)

Course Description: Difference equations, operators, numerical solutions of ordinary and partial differential equations. Programming in language such as Pascal, Fortran, or BASIC required.

Prerequisite(s): (ECS 032A or ENG 006 or EME 005 or ECS 030); (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B).

Learning Activities: Lecture 3 hour(s), Project.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 129 – Fourier Analysis (4 units)

Course Description: Fourier series and integrals, orthogonal sets of functions. Topics selected from trigonometric approximation, orthogonal polynomials, applications to signal and image processing, numerical analysis, and differential equations.

Prerequisite(s): MAT 021D; MAT 127A; (MAT 022A or MAT 027A or MAT 067 or BIS 027A); (MAT 022B or MAT 027B or BIS 027B);

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 133 – Mathematical Finance (4 units)

Course Description: Analysis and evaluation of deterministic and random cash flow streams, yield and pricing of basic financial instruments, interest rate theory, mean-variance portfolio theory, capital asset pricing models, utility functions and general principles. MATLAB programming required.

Prerequisite(s): (MAT 067 or MAT 022A or MAT 027A or BIS 027A); MAT 108; MAT 135A

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

MAT 135A – Probability (4 units)

Course Description: Probability space; discrete probability, combinatorial analysis; independence, conditional probability; random variables, discrete and continuous distributions, probability mass function, joint and marginal density functions; expectation, moments, variance, Chebyshev inequality; sums of random variables, random walk, large number law, central limit theorem.

Prerequisite(s): MAT 021C; (MAT 108 or MAT 067).

Learning Activities: Lecture/Discussion 4 hour(s).

Credit Limitation(s): Not open for credit to students who have completed former MAT 131.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 135B – Stochastic Processes (4 units)

Course Description: Generating functions, branching processes, characteristic function; Markov chains; convergence of random variables, law of iterated logarithm; random processes, Brownian motion, stationary processes, renewal processes, queueing theory, martingales.

Prerequisite(s): MAT 135A; (MAT 022A or MAT 027A or MAT 067 or BIS 027A).

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 141 – Euclidean Geometry (4 units)

Course Description: Axiomatic and analytic examination of Euclidean geometry from an advanced point of view. In particular, a discussion of its relation to other geometries. Designed to serve as preparation for the more rigorous upper division courses.

Prerequisite(s): MAT 021B; (MAT 022A or MAT 027A or MAT 067 or BIS 027A).

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 145 – Combinatorics (4 units)

Course Description: Combinatorial methods using basic graph theory, counting methods, generating functions, and recurrence relations. Designed to serve as preparation for the more rigorous upper division courses.

Prerequisite(s): MAT 021C.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 146 – Algebraic Combinatorics (4 units)

Course Description: Enumeration, Polya theory, generating functions, current topics in algebraic combinatorics.

Prerequisite(s): ((MAT 022A or MAT 027A or BIS 027A, MAT 108) or MAT 067)); MAT 145.

Learning Activities: Lecture/Discussion 4 hour(s).

Credit Limitation(s): Not open for credit to students who have completed former MAT 149A.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 147 – Topology (4 units)

Course Description: Basic notions of point-set and combinatorial topology.

Prerequisite(s): MAT 127A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 148 – Discrete Mathematics (4 units)

Course Description: Coding theory, error correcting codes, finite fields and the algebraic concepts needed in their development.

Prerequisite(s): MAT 067 or (MAT 022A or MAT 027A or BIS 027A, MAT 108).

Learning Activities: Lecture/Discussion 4 hour(s).

Credit Limitation(s): Not open for credit to students who have completed former MAT 149B.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 150A – Modern Algebra (4 units)

Course Description: Basic concepts of groups, symmetries of the plane. Emphasis on the techniques used in the proof of the ideas (Lemmas, Theorems, etc.) developing these concepts. Precise thinking, proof writing, and the ability to deal with abstraction.

Prerequisite(s): MAT 067 or (MAT 022A or MAT 027A or BIS 027A, MAT 108).

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 150B – Modern Algebra (4 units)

Course Description: Bilinear forms, rings, factorization, modules.

Prerequisite(s): MAT 150A.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 150C – Modern Algebra (4 units)

Course Description: Group representations, fields, Galois theory.

Prerequisite(s): MAT 150B.

Learning Activities: Lecture/Discussion 4 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 165 – Mathematics & Computers (4 units)

Course Description: Introduction to computational mathematics, symbolic computation, and computer generated/verified proofs in algebra, analysis and geometry. Investigation of rigorous new mathematics developed in conjunction with modern computational questions and the role that computers play in mathematical conjecture and experimentation.

Prerequisite(s): (MAT 127A or MAT 108 or MAT 114 or MAT 115A or MAT 145); (MAT 022A or MAT 027A or MAT 067 or BIS 027A).

Learning Activities: Lecture 3 hour(s), Project.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 167 – Applied Linear Algebra (4 units)

Course Description: Applications of linear algebra; LU and QR matrix factorizations, eigenvalue and singular value matrix decompositions.

Prerequisite(s): MAT 022A or MAT 027A or BIS 027A or MAT 067.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 168 – Optimization (4 units)

Course Description: Linear programming, simplex method. Basic properties of unconstrained nonlinear problems, descent methods, conjugate direction method. Constrained minimization. Programming language required.

Prerequisite(s): MAT 021C; ((MAT 022A or MAT 027A or BIS 027A, MAT 108) or MAT 067)).

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE); Quantitative Literacy (QL).

MAT 170 – Mathematics for Data Analytics & Decision Making (4 units)

Course Description: Relational model; relational algebra, relational calculus, normal forms, functional and multivalued dependencies, separability. Cost benefit analysis of physical database design and reorganization. Performance via analytical modeling, simulation, and queueing theory. Block accesses; buffering; operating system contention; CPU intensive operations.

Prerequisite(s): MAT 167 or MAT 128B or ECS 130.

Learning Activities: Lecture 3 hour(s), Project.

Enrollment Restriction(s): Pass One open to Applied Mathematics, Mathematics, Mathematics & Scientific Computation, Mathematical Analytics & Operations Research and Statistics Majors.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 180 – Special Topics (3 units)

Course Description: Special topics from various fields of modern, pure, and applied mathematics. Some recent topics include Knot Theory, General Relativity, and Fuzzy Sets.

Prerequisite(s): (MAT 067 or (MAT 022A or MAT 027A or BIS 027A, MAT 108)), MAT 127A.

Learning Activities: Lecture 3 hour(s).

Repeat Credit: May be repeated when topic differs.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 185A – Complex Analysis (4 units)

Course Description: Complex number system, analyticity and the Cauchy-Riemann equations, elementary functions, complex integration, power and Laurent series expansions, residue theory.

Prerequisite(s): (MAT 067 or (MAT 022A or MAT 027A or BIS 027A, MAT 108)), MAT 127B.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 185B – Complex Analysis (4 units)

Course Description: Analytical functions, elementary functions and their mapping properties, applications of Cauchy's integral theorem, conformal mapping and applications to heat flow and fluid mechanics.

Prerequisite(s): MAT 185A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

General Education: Science & Engineering (SE).

MAT 189 – Advanced Problem Solving (3 units)

Course Description: Solution and presentation of advanced problem solving techniques. Solve and present interesting and challenging problems of all areas of mathematics.

Prerequisite(s): ((MAT 022A, MAT 027A or BIS 027A, MAT 108) or MAT 067); MAT 127A.

Learning Activities: Lecture 3 hour(s).

Grade Mode: Letter.

General Education: Science & Engineering (SE); Oral Skills (OL); Quantitative Literacy (QL); Writing Experience (WE).

MAT 192 – Internship in Applied Mathematics (1-3 units)

Course Description: Supervised work experience in applied mathematics. Final report.

Prerequisite(s): Consent of instructor.

Learning Activities: Internship.

Repeat Credit: May be repeated 10 unit(s).

Grade Mode: Pass/No Pass only.

MAT 194 – Undergraduate Thesis (3 units)

Course Description: Independent research under supervision of a faculty member. Student will submit written report in thesis form.

Prerequisite(s): Consent of instructor.

Learning Activities: Independent Study.

Repeat Credit: May be repeated with consent of Vice Chairperson.

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE).

MAT 197TC – Tutoring Mathematics in the Community (1-5 units)

Course Description: Special projects in mathematical education developing techniques for mathematics instruction and tutoring on an individual or small group basis.

Prerequisite(s): Consent of instructor.

Learning Activities: Seminar 1-2 hour(s), Laboratory 2-6 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Pass/No Pass only.

MAT 198 – Directed Group Study (1-5 units)

Course Description: May be taught abroad.

Prerequisite(s): Consent of instructor.

Learning Activities: Variable.

Grade Mode: Pass/No Pass only.

MAT 199 – Special Study for Advanced Undergraduates (1-5 units)

Course Description: Special study for advanced undergraduates.

Learning Activities: Variable.

Grade Mode: Pass/No Pass only.

General Education: Science & Engineering (SE).

MAT 200 – Problem-Solving in Analysis (3 units)

Course Description: Problem-solving in graduate analysis: continuous functions, metric spaces, Banach & Hilbert spaces, bounded linear operators, the spectral theorem, distributions, Fourier series & transforms, L_p spaces, Sobolev spaces.

Prerequisite(s): MAT 201A (can be concurrent); MAT 201B (can be concurrent).

Learning Activities: Lecture 1 hour(s), Extensive Problem Solving.

Grade Mode: Satisfactory/Unsatisfactory only.

MAT 201A – Analysis (4 units)

Course Description: Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. L_p and Sobolev spaces. Differential calculus and variational methods.

Prerequisite(s): Graduate standing in Mathematics or Applied Mathematics, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 201B – Analysis (4 units)

Course Description: Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. L_p and Sobolev spaces. Differential calculus and variational methods.

Prerequisite(s): Graduate standing in Mathematics or Applied Mathematics, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 201C – Analysis (4 units)

Course Description: Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. L_p and Sobolev spaces. Differential calculus and variational methods.

Prerequisite(s): Graduate standing in Mathematics or Applied Mathematics, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 202 – Functional Analysis (4 units)

Course Description: Hahn-Banach, Open mapping, Closed graph, Banach-Steinhaus, and Krein-Milman. Subspaces and quotient spaces. Projections. Weak and weak-star topologies. Compact and adjoint operators in Banach spaces. Fredholm theory. Functions of operators. Spectral theory of self-adjoint operators.

Prerequisite(s): MAT 201A; MAT 201B.

Learning Activities: Lecture 3 hour(s), Term Paper.

Grade Mode: Letter.

MAT 205 – Complex Analysis (4 units)

Course Description: Analytic continuation, Riemann surfaces, conformal mappings, Riemann mapping theorem, entire functions, special functions, elliptic functions.

Prerequisite(s): MAT 185A; or equivalent to MAT 185A, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 205A – Complex Analysis (4 units)

Course Description: Cauchy's theorem, Cauchy's integral formulas, meromorphic functions, complex logarithm, entire functions, Weierstrass infinite product formula, the gamma and zeta functions, and prime number theorem.

Prerequisite(s): MAT 185A; or equivalent to MAT 185A, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Credit Limitation(s): No credit given to students who have completed MAT 205.

Grade Mode: Letter.

MAT 205B – Complex Analysis (4 units)

Course Description: Conformal mappings, the Schwarz lemma, analytic automorphisms, the Riemann mapping theorem, elliptic functions, Eisenstein series, the Jacobi theta functions, asymptotics, Bessel functions, the Airy function, topics on special functions and Riemann surfaces.

Prerequisite(s): MAT 205A; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Repeat Credit: May be repeated 2 time(s) when topic differs.

Grade Mode: Letter.

MAT 206 – Measure Theory (4 units)

Course Description: Introduction to measure theory. The study of lengths, surface areas, and volumes in general spaces, as related to integration theory.

Prerequisite(s): MAT 125B.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

MAT 207A – Methods of Applied Mathematics (4 units)

Course Description: Ordinary differential equations and dynamical systems. Variational principles. Eigenfunctions, integral equations and Green's functions. Complex analysis and contour integration. Laplace's equation. Diffusion equations. Wave phenomena. Dimensional analysis and scaling. Asymptotic expansions and perturbation theory. Stochastic processes and Brownian motion.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 207B – Methods of Applied Mathematics (4 units)

Course Description: Ordinary differential equations and dynamical systems. Variational principles. Eigenfunctions, integral equations and Green's functions. Complex analysis and contour integration. Laplace's equation. Diffusion equations. Wave phenomena. Dimensional analysis and scaling. Asymptotic expansions and perturbation theory. Stochastic processes and Brownian motion.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 207C – Methods of Applied Mathematics (4 units)

Course Description: Ordinary differential equations and dynamical systems. Variational principles. Eigenfunctions, integral equations and Green's functions. Complex analysis and contour integration. Laplace's equation. Diffusion equations. Wave phenomena. Dimensional analysis and scaling. Asymptotic expansions and perturbation theory. Stochastic processes and Brownian motion.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 215A – Topology (4 units)

Course Description: Fundamental group and covering space theory. Homology and cohomology. Manifolds and duality. CW complexes. Fixed point theorems.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 215B – Topology (4 units)

Course Description: Fundamental group and covering space theory. Homology and cohomology. Manifolds and duality. CW complexes. Fixed point theorems.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 215C – Topology (4 units)

Course Description: Fundamental group and covering space theory. Homology and cohomology. Manifolds and duality. CW complexes. Fixed point theorems.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 216 – Geometric Topology (4 units)

Course Description: Topology of two- and three-dimensional manifolds. Surfaces and their diffeomorphisms. Dehn twists. Heegaard surfaces. Theory of 3-dimensional manifolds. Knots and knot theory. Hyperbolic manifolds and geometric structures.

Prerequisite(s): MAT 215A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 218A – Partial Differential Equations (4 units)

Course Description: Year-long sequence on PDEs which covers linear transport, Laplace, heat, and wave equations, maximum principles, method of characteristics, Sobolev and Hölder space theory, weak derivatives, semilinear, quasilinear, and fully nonlinear elliptic/parabolic equations, nonlinear hyperbolic equations, and compensated compactness.

Prerequisite(s): MAT 201A; MAT 201B; MAT 201C; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 218B – Partial Differential Equations (4 units)

Course Description: Year-long sequence on PDEs which covers linear transport, Laplace, heat, and wave equations, maximum principles, method of characteristics, Sobolev and Hölder space theory, weak derivatives, semilinear, quasilinear, and fully nonlinear elliptic/parabolic equations, nonlinear hyperbolic equations, and compensated compactness.

Prerequisite(s): MAT 218A; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 218C – Partial Differential Equations (4 units)

Course Description: Year-long sequence on PDEs which covers linear transport, Laplace, heat, and wave equations, maximum principles, method of characteristics, Sobolev and Hölder space theory, weak derivatives, semilinear, quasilinear, and fully nonlinear elliptic/parabolic equations, nonlinear hyperbolic equations, and compensated compactness.

Prerequisite(s): MAT 218B; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 221A – Mathematical Fluid Dynamics (4 units)

Course Description: Kinematics and dynamics of fluids. The Euler and Navier-Stokes equations. Vorticity dynamics. Irrotational flow. Low Reynolds number flows and the Stokes equations. High Reynolds number flows and boundary layers. Compressible fluids. Shock waves.

Prerequisite(s): MAT 118B; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 221B – Mathematical Fluid Dynamics (4 units)

Course Description: Kinematics and dynamics of fluids. The Euler and Navier-Stokes equations. Vorticity dynamics. Irrotational flow. Low Reynolds number flows and the Stokes equations. High Reynolds number flows and boundary layers. Compressible fluids. Shock waves.

Prerequisite(s): MAT 118B; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 226A – Numerical Methods: Fundamentals (4 units)

Course Description: Fundamental principles and methods in numerical analysis, including the concepts of stability of algorithms and conditioning of numerical problems, numerical methods for interpolation and integration, eigenvalue problems, singular value decomposition and its applications.

Prerequisite(s): MAT 128A; MAT 128B; or equivalent, or consent of instructor; familiarity with some programming language.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 226B – Numerical Methods: Large-Scale Matrix Computations (4 units)

Course Description: Numerical methods for large-scale matrix computations, including direct and iterative methods for the solution of linear systems, the computation of eigenvalues and singular values, the solution of least-squares problems, matrix compression, methods for the solution of linear programs.

Prerequisite(s): MAT 167; or equivalent, or consent of instructor; familiarity with some programming language.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 226C – Numerical Methods: Ordinary Differential Equations (4 units)

Course Description: Numerical methods for the solution of ordinary differential equations, including methods for initial-value problems and two-point boundary-value problems, theory of and methods for differential algebraic equations, dimension reduction of large-scale dynamical systems.

Prerequisite(s): MAT 022B; or equivalent, or consent of instructor; familiarity with some programming language.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 227 – Mathematical Biology (4 units)

Course Description: Nonlinear ordinary and partial differential equations and stochastic processes of cell and molecular biology. Scaling, qualitative, and numerical analysis of mathematical models. Applications to nerve impulse, chemotaxis, muscle contraction, and morphogenesis.

Prerequisite(s): Graduate standing or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 228A – Numerical Solution of Differential Equations (4 units)

Course Description: Numerical solutions of initial-value, eigenvalue and boundary-value problems for ordinary differential equations. Numerical solution of parabolic and hyperbolic partial differential equations.

Prerequisite(s): MAT 128C.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s), Discussion.

Grade Mode: Letter.

MAT 228B – Numerical Solution of Differential Equations (4 units)

Course Description: Numerical solutions of initial-value, eigenvalue and boundary-value problems for ordinary differential equations. Numerical solution of parabolic and hyperbolic partial differential equations.

Prerequisite(s): MAT 128C.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s), Discussion.

Grade Mode: Letter.

MAT 228C – Numerical Solution of Differential Equations (4 units)

Course Description: Numerical solutions of initial-value, eigenvalue and boundary-value problems for ordinary differential equations. Numerical solution of parabolic and hyperbolic partial differential equations.

Prerequisite(s): MAT 128C.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s), Discussion.

Grade Mode: Letter.

MAT 235A – Probability Theory (4 units)

Course Description: Measure-theoretic foundations, abstract integration, independence, laws of large numbers, characteristic functions, central limit theorems. Weak convergence in metric spaces, Brownian motion, invariance principle. Conditional expectation. Topics selected from: martingales, Markov chains, ergodic theory.

Prerequisite(s): MAT 125B; (MAT 135A or STA 131A); or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Cross Listing: STA 235A.

Grade Mode: Letter.

MAT 235B – Probability Theory (4 units)

Course Description: Measure-theoretic foundations, abstract integration, independence, laws of large numbers, characteristic functions, central limit theorems. Weak convergence in metric spaces, Brownian motion, invariance principle. Conditional expectation. Topics selected from: martingales, Markov chains, ergodic theory.

Prerequisite(s): MAT 235A or STA 235A; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Cross Listing: STA 235B.

Grade Mode: Letter.

MAT 235C – Probability Theory (4 units)

Course Description: Measure-theoretic foundations, abstract integration, independence, laws of large numbers, characteristic functions, central limit theorems. Weak convergence in metric spaces, Brownian motion, invariance principle. Conditional expectation. Topics selected from: martingales, Markov chains, ergodic theory.

Prerequisite(s): MAT 235B or STA 235B; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Cross Listing: STA 235C.

Grade Mode: Letter.

MAT 236A – Stochastic Dynamics & Applications (4 units)

Course Description: Stochastic processes, Brownian motion, Stochastic integration, martingales, stochastic differential equations. Diffusions, connections with partial differential equations, mathematical finance.

Prerequisite(s): MAT 201C or (MAT 235B or STA 235B); MAT 235A,

MAT 235B, MAT 235C/STA 235A, STA 235B, STA 235C recommended.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 236B – Stochastic Dynamics & Applications (4 units)

Course Description: Stochastic processes, Brownian motion, Stochastic integration, martingales, stochastic differential equations. Diffusions, connections with partial differential equations, mathematical finance.

Prerequisite(s): MAT 201C or (MAT 235B or STA 235B); MAT 235A,

MAT 235B, MAT 235C/STA 235A, STA 235B, STA 235C recommended.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 239 – Differential Topology (4 units)

This version has ended; see updated course, below.

Course Description: Topics include: differentiable manifolds, vector fields, transversality, Sard's theorem, examples of differentiable manifolds; orientation, intersection theory, index of vector fields; differential forms, integration, Stokes' theorem, deRham cohomology; Morse functions, Morse lemma, index of critical points.

Prerequisite(s): MAT 201A; or consent of instructor; Vector calculus, point-set topology; MAT 250A MAT 250B highly recommended.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

MAT 239 – Differential Topology (4 units)

Course Description: Differentiable manifolds, vector fields, transverse intersections, Sard's Theorem, orientations, intersection theory, the index of a vector field, differential forms, integration on manifolds, Stokes' Theorem, deRham cohomology, Morse functions, the Morse lemma, and the index of critical points.

Prerequisite(s): MAT 201A; or consent of instructor; Vector calculus, point-set topology; MAT 250A & MAT 250B highly recommended.

Learning Activities: Lecture 3 hour(s), Discussion 1 hour(s).

Grade Mode: Letter.

This course version is effective from, and including: Spring Quarter 2023.

MAT 240A – Differential Geometry (4 units)

Course Description: Riemannian metrics, connections, geodesics, Gauss lemma, convex neighborhoods, curvature tensor, Ricci and scalar curvature, connections and curvature on vector bundles.

Prerequisite(s): MAT 201A; MAT 239; MAT 250A MAT 250B highly recommended; intended primarily for second-year graduate students.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 240B – Differential Geometry (4 units)

Course Description: Jacobi fields, conjugate points, completeness, Hopf-Rinow theorem, Cartan-Hadamard theorem, energy, variation theorems and their applications, Rauch comparison theorem and its applications.

Prerequisite(s): MAT 240A; Intended primarily for second-year graduate students.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 245 – Enumerative Combinatorics (4 units)

Course Description: Introduction to modern combinatorics and its applications. Emphasis on enumerative aspects of combinatorial theory.
Prerequisite(s): MAT 145; MAT 150; or the equivalent, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.
Grade Mode: Letter.

MAT 246 – Algebraic Combinatorics (4 units)

Course Description: Algebraic and geometric aspects of combinatorics. The use of structures such as groups, polytopes, rings, and simplicial complexes to solve combinatorial problems.

Prerequisite(s): MAT 245; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.
Grade Mode: Letter.

MAT 248A – Algebraic Geometry (4 units)

Course Description: Affine varieties and radical ideals. Projective varieties. Abstract varieties. Morphisms and rational maps. Smoothness. Algebraic curves and the Riemann-Roch theorem. Special topics.

Prerequisite(s): MAT 250A; MAT 250B; MAT 250C.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.
Grade Mode: Letter.

MAT 248B – Algebraic Geometry (4 units)

Course Description: Complex varieties and the analytic topology. Sheaves and schemes. Fiber products. Separatedness and properness. Applications of scheme theory.

Prerequisite(s): MAT 248A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.
Grade Mode: Letter.

MAT 249 – Problem-Solving in Algebra (3 units)

Course Description: Problem-solving in graduate algebra: groups, rings, modules, matrices, tensor products, representations, Galois theory, ring extensions, commutative algebra and homological algebra.

Prerequisite(s): MAT 250A (can be concurrent); MAT 250B (can be concurrent).

Learning Activities: Lecture 1 hour(s), Extensive Problem Solving.
Grade Mode: Satisfactory/Unsatisfactory only.

MAT 250A – Algebra (4 units)

Course Description: Group and rings. Sylow theorems, abelian groups, Jordan-Holder theorem. Rings, unique factorization. Algebras, and modules. Fields and vector spaces over fields. Field extensions. Commutative rings. Representation theory and its applications.

Prerequisite(s): Graduate standing in mathematics or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 250B – Algebra (4 units)

Course Description: Group and rings. Sylow theorems, abelian groups, Jordan-Holder theorem. Rings, unique factorization. Algebras, and modules. Fields and vector spaces over fields. Field extensions. Commutative rings. Representation theory and its applications.

Prerequisite(s): Graduate standing in mathematics or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 250C – Algebra (4 units)

Course Description: Group and rings. Sylow theorems, abelian groups, Jordan-Holder theorem. Rings, unique factorization. Algebras, and modules. Fields and vector spaces over fields. Field extensions. Commutative rings. Representation theory and its applications.

Prerequisite(s): Graduate standing in mathematics or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 258A – Numerical Optimization (4 units)

Course Description: Numerical methods for infinite dimensional optimization problems. Newton and Quasi-Newton methods, linear and sequential quadratic programming, barrier methods; large-scale optimization; theory of approximations; infinite and semi-infinite programming; applications to optimal control, stochastic optimization and distributed systems.

Prerequisite(s): MAT 025; MAT 167.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 258B – Discrete & Mixed-Integer Optimization (4 units)

Course Description: Combinatorial, integer, and mixed-integer linear optimization problems. Ideal and strong formulations, cutting planes, branch and cut, decomposition methods.

Prerequisite(s): MAT 025; MAT 167; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 261 – Lie Groups & Lie Algebras (4 units)

Course Description: Lie groups, examples and topological properties. Lie algebras and representation theory, and semisimple Lie algebras.

Prerequisite(s): MAT 147 and MAT 150A strongly encouraged; or equivalent; MAT 250A and MAT 215A and MAT 239 (can be concurrent) recommended.

Learning Activities: Lecture 3 hour(s); Extensive Problem Solving.

Enrollment Restriction(s): Open to graduate students only; or consent of instructor.

Grade Mode: Letter.

MAT 261A – Lie Groups & Their Representations (4 units)

Starting Spring Quarter 2023, this course is no longer offered.

Course Description: Lie groups and Lie algebras. Classification of semi-simple Lie groups. Classical and compact Lie groups. Representations of Lie groups and Lie algebras. Root systems, weights, Weil character formula. Kac-Moody and Virasoro algebras. Applications.

Prerequisite(s): MAT 215A; MAT 240A; MAT 250A; MAT 250B; or the equivalent, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).
Grade Mode: Letter.

MAT 261B – Lie Groups & Their Representations (4 units)

Starting Spring Quarter 2023, this course is no longer offered.

Course Description: Lie groups and Lie algebras. Classification of semi-simple Lie groups. Classical and compact Lie groups. Representations of Lie groups and Lie algebras. Root systems, weights, Weil character formula. Kac-Moody and Virasoro algebras. Applications.

Prerequisite(s): MAT 215A; MAT 240A; MAT 250A; MAT 250B; or the equivalent, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 265 – Mathematical Quantum Mechanics (4 units)

Course Description: Mathematical foundations of quantum mechanics: the Hilbert space and Operator Algebra formulations; the Schrödinger and Heisenberg equations, symmetry in quantum mechanics, basics of spectral theory and perturbation theory. Applications to atoms and molecules. The Dirac equation.

Prerequisite(s): MAT 201; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Grade Mode: Letter.

MAT 266 – Mathematical Statistical Mechanics & Quantum Field Theory (4 units)

Course Description: Mathematical principles of statistical mechanics and quantum field theory. Topics include classical and quantum lattice systems, variational principles, spontaneous symmetry breaking and phase transitions, second quantization and Fock space, and fundamentals of quantum field theory.

Prerequisite(s): MAT 265; or consent of instructor.

Learning Activities: Lecture 3 hour(s), Term Paper/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 270 – Mathematics of Data Science (4 units)

Course Description: Mathematical methods and algorithms that are fundamental to a variety of data science applications. Theoretical foundations and inner workings of popular algorithms used in data science, machine learning, and artificial intelligence. Implementation and application of these algorithms to real-world data sets.

Prerequisite(s): MAT 127A; MAT 167; MAT 135A.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Enrollment Restriction(s): Open to Graduate Students; undergraduate students obtain consent of instructor.

Grade Mode: Letter.

MAT 271 – Applied & Computational Harmonic Analysis (4 units)

Course Description: Introduction to mathematical basic building blocks (wavelets, local Fourier basis, and their relatives) useful for diverse fields (signal and image processing, numerical analysis, and statistics). Emphasis on the connection between the continuum and the discrete worlds.

Prerequisite(s): (MAT 125B or MAT 201C); (MAT 128B or MAT 167);

MAT 129; or the equivalent, or consent of instructor.

Learning Activities: Lecture 3 hour(s), Extensive Problem Solving.

Grade Mode: Letter.

MAT 280 – Topics in Pure & Applied Mathematics (3 units)

Course Description: Special topics in various fields of pure and applied mathematics. Topics selected based on the mutual interests of students and faculty.

Prerequisite(s): Graduate standing.

Learning Activities: Lecture 3 hour(s).

Repeat Credit: May be repeated when topic differs.

Grade Mode: Letter.

MAT 290 – Seminar (1-6 units)

Course Description: Advanced study in various fields of mathematics, including analysis, applied mathematics, discrete mathematics, geometry, mathematical biology, mathematical physics, optimization, partial differential equations, probability, and topology.

Learning Activities: Seminar 1-6 hour(s).

Repeat Credit: May be repeated.

Grade Mode: Satisfactory/Unsatisfactory only.

MAT 298 – Group Study (1-5 units)

Course Description: Group study.

Learning Activities: Variable.

Grade Mode: Letter.

MAT 299 – Individual Study (1-12 units)

Course Description: Individual study.

Learning Activities: Variable.

Grade Mode: Satisfactory/Unsatisfactory only.

MAT 299D – Dissertation Research (1-12 units)

Course Description: Dissertation research.

Learning Activities: Variable.

Grade Mode: Satisfactory/Unsatisfactory only.

MAT 301A – Mathematics Teaching Practicum (3 units)

Course Description: Specialist training in mathematics teaching. Teaching, training, and cross observing classes taught using large group Socratic techniques, small group guided inquiry experiences, and/or other approaches to teaching at various grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 302A (can be concurrent); MAT 303A (can be concurrent); MAT 302A MAT 303A required concurrently or consent of instructor.

Learning Activities: Fieldwork 5 hour(s), Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 301B – Mathematics Teaching Practicum (3 units)

Course Description: Specialist training in mathematics teaching. Teaching, training, and cross observing classes taught using large group Socratic techniques, small group guided inquiry experiences, and/or other approaches to teaching at various grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 302B (can be concurrent); MAT 303B (can be concurrent); MAT 302B MAT 303B required concurrently or consent of instructor.

Learning Activities: Fieldwork 5 hour(s), Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 301C – Mathematics Teaching Practicum (3 units)

Course Description: Specialist training in mathematics teaching. Teaching, training, and cross observing classes taught using large group Socratic techniques, small group guided inquiry experiences, and/or other approaches to teaching at various grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 302C (can be concurrent); MAT 303B (can be concurrent); MAT 302C MAT 303C required concurrently or consent of instructor.

Learning Activities: Fieldwork 5 hour(s), Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 302A – Curriculum Development in Mathematics (1 unit)

Course Description: Mathematics curriculum development for all grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 303A required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 302B – Curriculum Development in Mathematics (1 unit)

Course Description: Mathematics curriculum development for all grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 303B required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 302C – Curriculum Development in Mathematics (1 unit)

Course Description: Mathematics curriculum development for all grade levels. Required for advanced degrees in mathematics education.

Prerequisite(s): MAT 303C required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated.

Grade Mode: Letter.

MAT 303A – Mathematics Pedagogy (1 unit)

Course Description: An investigation of the interplay of mathematical pedagogy and mathematical content, including a historical survey of past and present methods in view of some of the influences that shaped their development.

Prerequisite(s): MAT 302A or MAT 210AL required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 303B – Mathematics Pedagogy (1 unit)

Course Description: An investigation of the interplay of mathematical pedagogy and mathematical content, including a historical survey of past and present methods in view of some of the influences that shaped their development.

Prerequisite(s): MAT 302A or MAT 210AL required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 303C – Mathematics Pedagogy (1 unit)

Course Description: An investigation of the interplay of mathematical pedagogy and mathematical content, including a historical survey of past and present methods in view of some of the influences that shaped their development.

Prerequisite(s): MAT 302C or MAT 210CL required concurrently or consent of instructor.

Learning Activities: Lecture/Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Letter.

MAT 390 – Teaching Assistantship Training (3 units)

Course Description: Experience in methods of assisting and teaching of mathematics at the university level. Includes discussion of lecturing techniques, running discussion sessions, holding office hours, preparing and grading of examinations, student-teacher interaction, and related topics. Required of departmental teaching assistants.

Prerequisite(s): Graduate standing in the Department of Mathematics.

Learning Activities: Lecture 3 hour(s).

Grade Mode: Satisfactory/Unsatisfactory only.

MAT 399 – Individual Study (2-4 units)

Course Description: Individual study of some aspect of mathematics education or a focused work on a curriculum design project under supervision of a faculty member in mathematics.

Learning Activities: Independent Study 2-3 hour(s), Discussion 1 hour(s).

Repeat Credit: May be repeated 1 time(s).

Grade Mode: Satisfactory/Unsatisfactory only.