MATH 1120  INTRODUCTION TO MATHEMATICAL AND COMPUTATIONAL THINKING (3 credits)
This course embraces the visual arts to introduce students to the foundational elements of mathematical and computational thinking. Visual patterns form the basis for explorations in arithmetic and geometric sequences, from which algebraic functions and corresponding functions in computer programs are reasoned.

Distribution: Math

MATH 1130 QUANTITATIVE LITERACY (3 credits)
Designed to equip students with the mathematical, statistical, and computational skills necessary to explore real-life situations. Students will learn and practice critical-thinking and problem-solving skills needed to use quantitative information to make responsible decisions in a variety of areas such as finance, health, and the environment.

Distribution: Math

MATH 1210 INTERMEDIATE ALGEBRA (3 credits)
This course is designed to prepare students to be successful in MATH 1220. Topics include simplifying mathematical expressions, the properties of equality, solving linear equations in one variable, using linear equations to solve problems, fractions, ratios and proportions, graphing and the rectangular coordinate system, relations and functions, systems of linear equations and inequalities in two variables, polynomial expressions and functions, factoring and solving polynomial equations. Credit earned in MATH 1210 will not count toward degree requirements.

Prerequisite(s)/Corequisite(s): ACT Math sub score of 18 or less, Math SAT at least 220 or Math SAT2016 at least 230 within the last 2 years; or Accuplacer score of 1 or 2 within the last 2 years; or MATH 1210 within the last 2 years.

MATH 1220 COLLEGE ALGEBRA (3 credits)
This course presents properties of real numbers, linear equations and graphing, systems of equations, linear inequalities, polynomials, algebraic fractions, exponents, logarithms, and an Introduction to Statistics. This course is designed to prepare students to be successful in MATH 1320 or MATH 1370. Students who have passed MATH 1310 with C- or better should not take this course.

Prerequisite(s)/Corequisite(s): Within last two years: ACT Math at least 19, SAT Math at least 460, SAT2016 Math at least 500, Accuplacer at least 3, MATH 1210 C- or better or MATH 1220 within last two years. Students who passed MATH 1310 with C- or better should not take MATH 1220.

Distribution: Math

MATH 1320 PRE-CALCULUS ALGEBRA (3 credits)
An advanced algebra course that teaches the following topics: algebraic operations, functions, graphs, linear and quadratic equations and inequalities, polynomial and rational functions, systems of equations, binomial theorem, complex numbers, exponentials, logarithms, sequences, series, and combinatorics.

Prerequisite(s)/Corequisite(s): ACT Math at least 23, Math SAT at least 540, or Math SAT2016 at least 570 last 2 years; or Accuplacer score at least 4 last 2 years; or MATH 1220 or MATH 1310 each with C- or better last 2 years; or MATH 1320 last 2 years

MATH 1330 TRIGONOMETRY (3 credits)
This course introduces elements of plane trigonometry, including trigonometric and circular functions, inverse trigonometric functions, solutions of triangles, identities and conditional equations, vectors, and conic sections.

Prerequisite(s)/Corequisite(s): ACT Math at least 25, Math SAT at least 570, or Math SAT2016 at least 590 within last 2 years; or Accuplacer at least 5 within last 2 years; or MATH 1320 with at least C- within last 2 years; or MATH 1330 within last 2 years
MATH 1970  CALCULUS III (4 credits)
This course presents vector functions, parametric equations, solid analytic geometry, partial differentiation, multiple integration, and an introduction to vector calculus. A mathematical software package is introduced with required assignments.
Prerequisite(s)/Corequisite(s): MATH 1960 with a grade of C- or better, or MATH 1970 with a grade of F or better, or permission of instructor.
MATH 2030  DISCRETE MATHEMATICS (3 credits)
A foundations course in discrete mathematics for applied disciplines, including computer science and computer engineering. Topics include: logic, sets, relations, functions, complexity functions and big congruences, induction and recursive definitions, elementary combinatorics, discrete probability, graphs and trees.
Prerequisite(s)/Corequisite(s): MATH 1950 or MATH 1930.
MATH 2050  APPLIED LINEAR ALGEBRA (3 credits)
This course presents Matrix algebra, simultaneous equations, vector spaces, with applications of linear algebra and computational considerations. Mathematical software is utilized, with required assignments.
Prerequisite(s)/Corequisite(s): MATH 1940 or MATH 1950 with a grade of C- or better
MATH 2200  MATHEMATICAL COMPUTING I (3 credits)
This is a first course in mathematical computing. It covers the basic elements of scientific programming in both a computer algebra system and a high-level programming language. Explored are implementation issues, problem description, model building, method development, and solution assessment.
Prerequisite(s)/Corequisite(s): MATH 1950
MATH 2220  INTRODUCTION TO ABSTRACT MATH (3 credits)
This course provides a transition from the calculus to more abstract mathematics. Topics include logic, sets and functions, an introduction to mathematical proof, mathematical induction, relations. Important prerequisite material for a number of more advanced mathematics courses is studied. Credit will not be given for both MATH 2030 (or MATH 2040) and MATH 2220.
Prerequisite(s)/Corequisite(s): MATH 1960 or permission
MATH 2350  DIFFERENTIAL EQUATIONS (3 credits)
Topics include solutions of linear and first-order nonlinear differential equations with applications, higher-order linear differential equations with applications, power series solutions, and Laplace transform methods.
Prerequisite(s)/Corequisite(s): MATH 1960 with a grade of C- or better or permission of instructor.
MATH 3100  APPLIED COMBINATORICS (3 credits)
Basic counting methods, generating functions, recurrence relations, principle of inclusion-exclusion. Polya’s formula. Elements of graph theory, trees and searching network algorithms. (Cross-listed with MATH 8105, CSCI 3100, CSCI 8105).
Prerequisite(s)/Corequisite(s): MATH 2030, MATH 2040, MATH 2230, or CSCI 2030 all with a C- or better. Mathematical logic; Set theory; Relations; Functions; Congruences; Inductive and recursive definitions; Discrete probability; sets, graphs, trees, & matrices
MATH 3200  MATHEMATICAL COMPUTING II (3 credits)
This course is a second course in mathematical computing. It covers the design and development of algorithms and more advanced elements of programming in a mathematical context. The computer algebra system Maple will be used. The programming assignments are primarily based on calculus concepts and are designed to reinforce and deepen the understanding of these concepts.
Prerequisite(s)/Corequisite(s): CIST 1400 or MATH 2200, and MATH 1970 (the latter may be taken concurrently)
MATH 3230  INTRODUCTION TO ANALYSIS (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include real number system, topology of the real line, limits, functions of one variable, continuity, differentiation, integration. (Cross-listed with MATH 8235).
Prerequisite(s)/Corequisite(s): MATH 1960 and MATH 2230
MATH 3300  NUMERICAL METHODS (3 credits)
This course involves solving nonlinear algebraic equations and systems of equations, interpolation and polynomial approximation, numerical differentiation and integration, numerical solutions to ordinary differential equations, analysis of algorithms and errors, and computational efficiency. (Cross-listed with MATH 8305, CSCI 3300, CSCI 8305).
Prerequisite(s)/Corequisite(s): MATH 1960 with a C- or better or permission of instructor
MATH 3400  MODERN GEOMETRY (3 credits)
Topics include hyperbolic geometry, Euclidean geometry, and non-Euclidean geometry. The course covers Euclidean, hyperbolic, and non-Euclidean geometries. (Cross-listed with MATH 8505).
Prerequisite(s)/Corequisite(s): MATH 2230
MATH 3500  SELECTED TOPICS IN MATHEMATICS (1-6 credits)
This is a variable content course with selected topics in the mathematical sciences which may be of interest to students in other disciplines such as mathematics education, psychology and business. The course may be taken more than once for credit provided topics differ, with a maximum of nine hours. Mathematics majors may apply no more than three hours of MATH 3500 toward the minimum major requirements. (Cross-listed with MATH 8505).
Prerequisite(s)/Corequisite(s): Permission of instructor.
MATH 3640  HISTORY OF MATHEMATICS (3 credits)
This is a variable content course with selected topics in the mathematical sciences which may be of interest to students in other disciplines such as mathematics education, psychology and business. The course may be taken more than once for credit provided topics differ, with a maximum of nine hours. Mathematics majors may apply no more than three hours of MATH 3500 toward the minimum major requirements. (Cross-listed with MATH 8505).
Prerequisite(s)/Corequisite(s): MATH 2230
MATH 3850  INTRODUCTION TO THE THEORY OF RECURSIVE FUNCTIONS (3 credits)
This is a variable content course with selected topics in the mathematical sciences which may be of interest to students in other disciplines such as mathematics education, psychology and business. The course may be taken more than once for credit provided topics differ, with a maximum of nine hours. Mathematics majors may apply no more than three hours of MATH 3500 toward the minimum major requirements. (Cross-listed with MATH 8505).
Prerequisite(s)/Corequisite(s): MATH 2230
MATH 4030 MODERN ALGEBRA (3 credits)
Algebra is the study of mathematical manipulations that preserve something (like equality - when solving equations). The areas in which Algebra finds application are quite diverse, from Ancient Greek Geometry through to Modern Information Protection and Security (error correcting codes, data compression, and cryptography). This course begins with topics that should be familiar (such as ruler-and-compass constructions, and modular arithmetic) and builds upon this foundation through polynomial rings up to finite fields and basic group theory. (Cross-listed with MATH 8036).
Prerequisite(s)/Corequisite(s): MATH 2230 with a C- or better or MATH 2030 with a C- or better

MATH 4050 LINEAR ALGEBRA (3 credits)
Linear algebra is extensively utilized in the mathematical modeling of many natural phenomena. Many scientific and engineering disciplines, such as data science, chemical engineering and biology, make extensive use of the theory and techniques commonly present in basic to advanced linear algebra courses. The goal of this course is to help students to grasp a solid theoretical understanding of vectors, vector spaces, inner product spaces, linear transformations, eigenvalues, canonical forms, complex vectors, matrices, and orthogonality. By going through the materials in a mathematically rigorous way, students will develop deeper and more accurate intuitions of the basic concepts in linear algebra. Consequently, the applications of linear algebra will become much more transparent. (Cross-listed with MATH 8056).
Prerequisite(s)/Corequisite(s): MATH 2050; MATH 2030 or MATH 2230 or equivalent; or permission

MATH 4110 ABSTRACT ALGEBRA I (3 credits)
An introduction to group theory. Various classes of group are studied: symmetric groups, abelian, cyclic, and permutation groups. Basic tools are developed and used: subgroups, normal subgroups, cosets, the Lagrange theorem, group homomorphisms, quotient groups, direct products, and group actions on a set. The course culminates with the Sylow theorems in finite group theory. The theory is illustrated with examples from geometry, linear algebra, number theory, crystallography, and combinatorics. (Cross-listed with MATH 8116).
Prerequisite(s)/Corequisite(s): MATH 4050/MATH 8056 with a C- or better or MATH 4560/MATH 8566 with a C- or better or permission of instructor

MATH 4120 ABSTRACT ALGEBRA II (3 credits)
An introduction to ring and field theory. Various classes of commutative rings are considered including polynomial rings, and the Gaussian integers. Examples of fields include finite fields and various extensions of the rational numbers. Concepts such as that of an ideal, integral domain, characteristic and extension field are studied. The course culminates with an introduction to Galois theory. Applications include the resolution of two classical problems: the impossibility of angle-trisection and the general insolvability of polynomial equations of degree 5 or higher. (Cross-listed with MATH 8126).
Prerequisite(s)/Corequisite(s): MATH 4110/MATH 8116 with a C- or better or permission of instructor

MATH 4150 GRAPH THEORY & APPLICATIONS (3 credits)
Introduction to graph theory. Representations of graphs and graph isomorphism. Trees as a special case of graphs. Connectivity, covering, matching and coloring in graphs. Directed graphs and planar graphs. Applications of graph theory in several fields such as networks, social sciences, VLSI, chemistry and parallel processing. (Cross-listed with MATH 8156, CSCI 4150, CSCI 8156).
Prerequisite(s)/Corequisite(s): CSCI 2030 with a C- or better, or MATH 2030 with a C- or better, or MATH 2230 with a C- or better, or permission of instructor.

MATH 4230 MATHEMATICAL ANALYSIS I (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include ordered fields and the real number system, basic properties of complex numbers, metric space topology, sequences and series in Rk, limits and continuity in a metric space, monotonic functions. (Cross-listed with MATH 8236).
Prerequisite(s)/Corequisite(s): MATH 3230/MATH 8235

MATH 4240 MATHEMATICAL ANALYSIS II (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include differentiation and Riemann-Stieltjes Integration, sequences and series of functions, uniform convergence, power series, functions of several variables, Implicit Function Theorem. (Cross-listed with MATH 8246).
Prerequisite(s)/Corequisite(s): MATH 4230

MATH 4270 COMPLEX VARIABLES (3 credits)
Differentiation, integration and power series expansions of analytic functions, conformal mapping, residue calculus and applications. (Cross-listed with MATH 8276).
Prerequisite(s)/Corequisite(s): MATH 3230/MATH 8235 or equivalent.

MATH 4300 DETERMINISTIC OPERATIONS RESEARCH MODELS (3 credits)
This is a survey course of deterministic operations research models and algorithms. Topics include linear programming, network programming, and integer programming. (Cross-listed with CSCI 4300, CSCI 8306, MATH 8306).
Prerequisite(s)/Corequisite(s): MATH 2050 with a C- or better or permission of instructor.

MATH 4310 PROBABILISTIC OPERATIONS RESEARCH MODELS (3 credits)
This is a survey course of probabilistic operations research models and algorithms. Topics include Markov chains, queueing theory, inventory models, forecasting, and simulation. (Cross-listed with CSCI 4310, CSCI 8316, MATH 8316).
Prerequisite(s)/Corequisite(s): MATH 2050 and either MATH 4740 or MATH 8746 or STAT 3800 or STAT 8805 all with a C- or better or permission of instructor.

MATH 4320 COMPUTATIONAL OPERATIONS RESEARCH (3 credits)
Survey of computational methods used in the solution of operations research problems. Topics include scripting to guide optimization software, metaheuristics for optimization, and basic machine learning algorithms. (Cross-listed with MATH 8326).
Prerequisite(s)/Corequisite(s): MATH 3200 and MATH 4300 each with a grade of C- or better or permission of instructor.

MATH 4330 INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS (3 credits)
This course introduces the basic methods of PDEs guided by applications in physics and engineering. The main topics to be covered include The Linear First order PDEs, Transport equations, Characteristics, Classification of PDEs, Separation of variables, Heat conduction, vibrating membranes, boundary value problems, Maximum principle, Sturm-Liouville problems, Fourier series, Fourier integrals, Harmonic functions, Legendre polynomials, Distributions, Green’s functions. (Cross-listed with MATH 8336).
Prerequisite(s)/Corequisite(s): MATH 1970 with a C- or better and MATH 2350 with a C- or better, or permission of instructor; MATH 2050 recommended, not required.

MATH 4350 ORDINARY DIFFERENTIAL EQUATIONS (3 credits)
This course covers the theory of initial-, boundary-, and eigenvalue problems, existence theorems, real and complex linear systems of differential equations, and stability theory. There will be a strong emphasis on methods for finding solutions of initial and boundary value problems and analyzing properties of these solutions for various ordinary differential equations. (Cross-listed with MATH 8356).
Prerequisite(s)/Corequisite(s): MATH 1970 with a C- or better, MATH 2050 with a C- or better, MATH 2350 with a C- or better, and MATH 2350 with a C- or better or instructor’s permission.
MATH 4400  FINITE ELEMENT METHODS FOR SOLVING ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS (3 credits)
Prerequisite(s)/Corequisite(s): MATH 1970 with a C- or better, MATH 2050 with a C- or better, and MATH 2350 with a C- or better, or instructor's permission. MATH 3300/MATH 8305 and MATH 4330/MATH 8336 are recommended, but not required. Familiarity with MATLAB programming is assumed.

MATH 4450  INTRODUCTION TO MACHINE LEARNING AND DATA MINING (3 credits)
This is an introduction to machine learning and data mining which covers the following topics with an emphasis on mathematical and statistical analysis: linear and nonlinear regression models, model selection and regularization methods, resampling methods, classification models, tree-based models, and unsupervised learning topics. If time allows, text mining and deep learning will also be introduced in the course. Statistical software will be used. (Cross-listed with MATH 8456, STAT 4450, STAT 8456)
Prerequisite(s)/Corequisite(s): MATH 4740/8746 with a C- or better or STAT 3800/8805 with a C- or better or permission of instructor.

MATH 4560  NUMBER THEORY & CRYPTOGRAPHY (3 credits)
An overview of one of the many beautiful areas of mathematics and its modern application to secure communication. The course is ideal for any student who wants a taste of mathematics outside of, or in addition to, the calculus sequence. Topics to be covered include: prime numbers, congruences, perfect numbers, primitive roots, quadratic reciprocity, sums of squares, and Diophantine equations. Applications include error-correcting codes, symmetric and public key cryptography, secret sharing, and zero knowledge proofs. (Cross-listed with MATH 8566, CSCI 4560, CSCI 8566).
Prerequisite(s)/Corequisite(s): MATH 2230 with a C- or better or MATH 2030 with a C- or better or MATH 2350 with a C- or better or permission of instructor.

MATH 4610  INTRODUCTION TO TOPOLOGY (3 credits)
This is a proof-oriented course presenting the foundations of topology. Metric spaces and general topological spaces are introduced. The course explores the properties of connectedness, compactness and completeness, and operations of Tychonoff product and hyperspace. (Cross-listed with MATH 8616).
Prerequisite(s)/Corequisite(s): MATH 3230 with a C- or better or MATH 4740 or MATH 8746.

MATH 4620  ITERATED FUNCTION SYSTEMS AND FRACTALS (3 credits)
This is a proof-oriented course presenting the foundations of fractal geometry. It introduces students to the beauty, magic, and importance of fractals and iterated function systems, with emphasis on the mathematics behind it all. Topics range from contractions on hyperspaces and their fixed points to fractal dimensions to Julia and Mandelbrot sets. (Cross-listed with MATH 8626).
Prerequisite(s)/Corequisite(s): MATH 4610 with a C- or better or permission of instructor.

MATH 4660  AUTOMATA, COMPUTABILITY, AND FORMAL LANGUAGES (3 credits)
This course presents a sampling of several important areas of theoretical computer science. Definition of formal models of computation and important properties of such models, including finite automata and Turing machines. Definition and important properties of formal grammars and their languages. Introduction to the formal theories of computability and complexity. (Cross-listed with CSCI 4660, CSCI 8666, MATH 8666)
Prerequisite(s)/Corequisite(s): MATH 2030. Recommended: CSCI 3320/CSCI 8325.

MATH 4740  INTRODUCTION TO PROBABILITY AND STATISTICS I (3 credits)
A mathematical introduction to probability theory including the properties of probability; probability distributions; expected values and moments; specific discrete and continuous distributions; and transformations of random variables. (Cross-listed with MATH 8746).
Prerequisite(s)/Corequisite(s): MATH 1970 and either MATH 2230 or MATH 2030 or permission of instructor.

MATH 4750  INTRODUCTION TO PROBABILITY AND STATISTICS II (3 credits)
Theory and methods of statistical inference including estimators, statistical hypotheses, multivariate estimation, chi-square tests, analysis of variance and statistical software. (Cross-listed with MATH 8756).
Prerequisite(s)/Corequisite(s): MATH 4740/MATH 8746

MATH 4760  TOPICS IN MODELING (3 credits)
Selection of such topics as formulation and analysis of various models involving Markov chains, Markov processes (including birth and death processes), queues, cellular automata, difference and differential equations, chaotic systems and fractal geometries. (Cross-listed with MATH 8766, CSCI 4760, CSCI 8766).
Prerequisite(s)/Corequisite(s): MATH 2350 and MATH 4740 or MATH 8746.

MATH 4900  INDEPENDENT STUDIES (1-3 credits)
A variable credit course for the junior or senior who will benefit from independent reading assignments and research-type problems. Independent study makes available courses of study not available in scheduled course offerings. The student wishing to take an independent study course should find a faculty member willing to supervise the course and then submit, for approval, a written proposal (including amount of credit) to the MATH/STAT Undergraduate Curriculum Committee at least one week prior to registration.
Prerequisite(s)/Corequisite(s): Junior and permission of the chair

MATH 4980  SEMINAR (1-3 credits)
A seminar in mathematics.
Prerequisite(s)/Corequisite(s): At least one math course numbered 3000 or above (not including MATH 3500) and permission.