MATH - Mathematics

Courses numbered 500 to 799 = undergraduate/graduate. (Individual courses may be limited to undergraduate students only.) Courses numbered 800 to 999 = graduate.

MATH 501. Elementary Mathematics (5).
A study of topics necessary to an understanding of the elementary school curriculum, such as set theory, real numbers and geometry. Not for major or minor credit. Prerequisites: elementary education major and MATH 111 or equivalent with a grade point of 2.000 or better, or departmental consent.

MATH 502. Mathematics for Middle School Teachers (5).
A study of the mathematical knowledge which forms the theoretical foundations of, the applications of, and extensions of middle school mathematics. This capstone course serves to reinforce mathematics skills learned in prerequisite courses and assists students in recognizing the unifying principles within their mathematical experiences. Prerequisites: MATH 111, 121, 123, 144, 501, and STAT 370 or equivalent with a grade point of 2.000 or better in each.

MATH 511. Linear Algebra (3).
An elementary study of linear algebra, including an examination of linear transformations and matrices over finite dimensional spaces. Prerequisite: MATH 243 with a grade point of 2.000 or better.

MATH 513. Fundamental Concepts of Algebra (3).
Defines group, ring and field, and studies their properties. Prerequisites: MATH 415 and 511 with a grade point of 2.000 or better, or departmental consent.

MATH 525. Elementary Topology (3).
Studies topological spaces, open and closed sets, bases for topology, continuous mappings, homeomorphisms, connectedness and compactness, Hausdorff and other spaces, with special emphasis on metric spaces. Prerequisite: MATH 415 with a grade point of 2.000 or better.

MATH 530. Applied Combinatorics (3).
Basic counting principles, occupancy problems, generating functions, recurrence relations, principles of inclusion and exclusion, the pigeonhole principle, Fibonacci sequences and elements of graph theory. Prerequisite: MATH 344 with a grade point of 2.000 or better.

MATH 531. Introduction to the History of Mathematics (3).
General education math and natural sciences advanced issues and perspectives course. Studies the development of mathematics from antiquity to modern times. Solves problems using the methods of the historical period in which they arose. Requires mathematical skills. Prerequisites: MATH 511 and two additional courses at the 500 level or above, with a grade point of 2.000 or better in each.

MATH 531H. Introduction to the History of Mathematics Honors (3).
General education math and natural sciences advanced issues and perspectives course. Studies the development of mathematics from antiquity to modern times. Solves problems using the methods of the historical period in which they arose. Requires mathematical skills. Prerequisites: MATH 511 and two additional courses at the 500 level or above, with a grade point of 2.000 or better in each.

MATH 545. Integration Techniques and Applications (3).
Studies the basic integration techniques used in applied mathematics. Includes the standard vector calculus treatment of line and surface integrals, Green’s Theorem, Stokes’s Theorem, and the Divergence Theorem. Also includes the study of improper integrals with application to special functions. Prerequisite: MATH 344 with a grade point of 2.000 or better.

MATH 547. Advanced Calculus I (3).
Covers the calculus of Euclidean space including the standard results concerning functions, sequences and limits. Prerequisites: MATH 344 and 415 with a grade point of 2.000 or better in each.

MATH 548. Introduction to Complex Variables (3).
Study of complex numbers, analytic functions, differentiation and integration of complex functions, line integrals, power series, residues and poles, and conformal mapping with applications. Prerequisites: MATH 344 with a grade point of 2.000 or better.

MATH 551. Numerical Methods (3).
Approximating roots of equations, interpolation and approximation, numerical differentiation and integration, and the numerical solution of first order ordinary differential equations. Some computer use. Prerequisites: MATH 344 and 451 with a grade point of 2.000 or better, or departmental consent.

MATH 553. Mathematical Models (3).
Covers case studies from the fields of engineering technology and the natural and social sciences. Emphasizes the mathematics involved. Each student completes a term project which is the solution of a particular problem approved by the instructor. Prerequisite: Math 344 with a grade point of 2.000 or better, or departmental consent.

MATH 555. Differential Equations I (3).
A study of first order equations including separation of variables and exact equations, second order equations including the general theory of initial value problems, constant coefficients, undetermined coefficients, variation of parameters and special methods of solution using power series and the Laplace transform methods. A standard course in differential equation for students in the sciences and engineering. Prerequisite: MATH 243 with a grade point of 2.000 or better, or departmental consent.

MATH 555I. Differential Equations I Honors (3).
A study of first order equations including separation of variables and exact equations, second order equations including the general theory of initial value problems, constant coefficients, undetermined coefficients, variation of parameters and special methods of solution using power series and the Laplace transform methods. A standard course in differential equation for students in the sciences and engineering. Prerequisite: MATH 243 with a grade point of 2.000 or better, or departmental consent.

MATH 580. Selected Topics In Math (1-3).
Topic chosen from topics not otherwise represented in the curriculum. May be repeated up to a maximum of 6 hours credit with departmental consent. Prerequisite: departmental consent.

MATH 615. Elementary Number Theory (3).
Studies properties of the integers by elementary means. Prerequisite: MATH 344 with a grade point of 2.000 or better, or departmental consent.

MATH 621. Elementary Geometry (3).
Studies Euclidean geometry from an advanced point of view. Prerequisite: MATH 344 with a grade point of 2.000 or better, or departmental consent.

MATH 640. Advanced Calculus II (3).
A continuation of MATH 547. Prerequisites: MATH 511 and 547 with a grade point of 2.000 or better in each.

MATH 655. Differential Equations II (3).
A continuation of MATH 555 (but with more emphasis on theoretical issues) that covers higher order differential equations, systems of
first order equations (including the basics of linear algebra), some numerical methods, and stability and behavior of solutions for large times. Prerequisite: MATH 555 with a grade point of 2.000 or better, or departmental consent.

**MATH 657. Optimization Theory** (3).
Introduces selected topics in linear and nonlinear optimization. Develops the revised simplex method along with a careful treatment of duality. Then extends the theory to solve parametric, integer and mixed integer linear programs. Prerequisite: MATH 511 with a grade point of 2.000 or better.

**MATH 713. Abstract Algebra I** (3).
Treats the standard basic topics of abstract algebra. Prerequisite: MATH 513 with a grade point of 2.000 or better, or departmental consent.

**MATH 720. Modern Geometry** (3).
Examines the fundamental concepts of geometry. Prerequisite: MATH 513 with a grade point of 2.000 or better, or departmental consent.

**MATH 725. Topology I** (3).
Studies the results of point set and algebraic topology. Prerequisite: MATH 547 with a grade point of 2.000 or better, or departmental consent.

**MATH 743. Real Analysis I** (3).
Includes a study of the foundations of analysis and the fundamental results of the subject. Prerequisite: MATH 640 with a grade point of 2.000 or better, or departmental consent.

**MATH 745. Complex Analysis I** (3).
Studies the theory of analytic functions. Prerequisite: MATH 640 with a grade point of 2.000 or better, or departmental consent.

**MATH 750Y. Smooth Manifolds** (3).
Knowledge of differentiable manifolds has become very important in a large number of areas of mathematics and of its applications. In fact, much of advanced calculus and analysis is based on the study of differentiable manifolds. For example, topics such as line and surface integrals, divergence and curl of vector fields and Stokes' and Green's theorems are most naturally described using manifold theory. Course gives a careful introduction to differentiable manifolds, illustrating each new definition and theorem with the study of spheres, tori, real and complex projective spaces, and matrix groups. Talks about tangent spaces, vector fields, differential forms and integral curves. Concludes with Stokes' theorem on manifolds.

**MATH 750Z. Data Analytics** (3).
Covers basic mathematical techniques for analyzing data sets. The course will use Python to show how to organize, visualize, and analyze large data. Prerequisite: MATH 511, STAT 571, basic programming knowledge.

**MATH 751. Numerical Linear Algebra** (3).
Includes analysis of direct and iterative methods for the solution of linear systems, linear least squares problems, Eigenvalue problems, error analysis, and reduction by orthogonal transformations. Prerequisites: MATH 511, 547, 551 with a grade point of 2.000 or better in each, or departmental consent.

**MATH 753. Ordinary Differential Equations** (3).
Covers existence, uniqueness, stability and other qualitative theories of ordinary differential equations. Prerequisite: MATH 545 or 547 with a grade point of 2.000 or better, or departmental consent.

**MATH 755. Partial Differential Equations I** (3).
Studies the existence and uniqueness theory for boundary value problems of partial differential equations of all types. Prerequisite: MATH 547 with a grade point of 2.000 or better, or departmental consent.

**MATH 757. Partial Differential Equations for Engineers** (3).
Includes Fourier series, the Fourier integral, boundary value problems for the partial differential equations of mathematical physics, Bessel and Legendre functions, and linear systems of ordinary differential equations. Prerequisite: MATH 555 with a grade point of 2.000 or better.

**MATH 758. Complex and Vector Analysis for Engineers** (3).
A survey of some of the mathematical techniques needed in engineering including an introduction to vector analysis, line and surface integrals, and complex analysis, contour integrals and the method of residues. Not applicable toward a graduate degree in mathematics. Prerequisite: MATH 555 with a grade point of 2.000 or better.

**MATH 781. Cooperative Education** (1-3).
Work-related placement with a supervised professional experience to complement and enhance the student's academic program. Intended for master's level or doctoral students in math. Repeatable for credit. May not be used to satisfy degree requirements. Prerequisites: departmental consent, graduate GPA of 3.000 or above.

**MATH 813. Abstract Algebra II** (3).
A continuation of MATH 713. Prerequisite: MATH 713 or equivalent.

**MATH 825. Topology II** (3).
A continuation of MATH 725. Prerequisite: MATH 725 or equivalent.

**MATH 828. Selected Topics Topology** (2-3).
Repeatable with departmental consent. Prerequisite: departmental consent.

**MATH 828G. Smooth Geometry** (3).
Begins with basic smooth manifold theory including topics such as vector bundles, tensor fields, flows, Lie derivatives and the theorems of Green, Gauss and Stokes. Introduces some elementary topics from Riemannian geometry.

**MATH 828J. Smooth Geometry II** (3).
Survey of topics in the areas of smooth manifold theory and Riemannian geometry. Emphasizes the Riemann Curvature Tensor and the relationship between topology and positive curvature.

**MATH 828K. Partial Differential Operator Theory** (3).
Introduces jet theory with the goal of proving Peetre's theorem. Studies sheaves, ringed spaces, and morphisms of each with the ultimate goal of proving Slovak's generalization of Peetre's theorem. Finally, investigates applications of the two main theorems.

**MATH 829. Selected Topics in Geometry** (2-3).
Repeatable with departmental consent. Prerequisite: departmental consent.

**MATH 843. Real Analysis II** (3).
A continuation of MATH 743. Prerequisite: MATH 743 or equivalent.

**MATH 845. Complex Analysis II** (3).
A continuation of MATH 745. Prerequisite: MATH 745 or equivalent.
MATH 848. Calculus of Variations (3).
Includes Euler-Lagrange equations, variational methods and applications to extremal problems in continuum mechanics.
Prerequisite: MATH 547 or 757.

MATH 849. Selected Topics in Analysis (2-3).
Repeatable with departmental consent. Prerequisite: departmental consent.

MATH 849G. Broad Topics in Analysis (3).
Seminal publications in mathematical analysis will be introduced, examined and discussed and incorporated into the research of participating students.

Prerequisites: MATH 555, 751.

Includes analysis of algorithms for the solution of initial value problems and boundary value problems for systems of PDEs with applications to fluid flow, structural mechanics, electromagnetic theory and control theory. Prerequisite: MATH 751.

MATH 854. Tensor Analysis with Applications (3).
After introducing tensor analysis, considers applications to continuum mechanics, structural analysis and numerical grid generation.
Prerequisite: MATH 545 or 757.

MATH 856. Partial Differential Equations II (3).
A continuation of MATH 755. Prerequisite: MATH 755.

MATH 857. Selected Topics in Engineering Mathematics (3).
Advanced topics in mathematics of interest to engineering students, including tensor analysis, calculus of variations and partial differential equations. Not applicable toward the MS in mathematics.

MATH 858. Selected Topics in Engineering Mathematics II (3).
Advanced topics in mathematics of interest to engineering students, including tensor analysis, calculus of variations and partial differential equations. Not applicable toward the MS in mathematics.

MATH 859. Selected Topics in Applied Mathematics (2-3).
Repeatable with departmental consent.

MATH 859K. Mathematical Physics (3).
Advanced topics of mathematics as applied to problems in quantum computing and quantum information. Includes mappings, simulations and diffeomorphisms of quantum measures.

MATH 859L. Mathematical Physics II (3).
Advanced topics of mathematics as applied to problems in quantum computing and quantum information. Includes mappings, simulations and diffeomorphisms of quantum measures.

MATH 859M. Computational Fluid Dynamics (3).
A study of the fundamental equations in fluid mechanics. In particular, discusses numerical solvers of the Euler equations and, in general, conservation laws. The numerical methods are applied to fluid dynamical problems in plasma physics and nuclear fusion.

MATH 859N. Math of Machine Learning I (3).
Study of complex and quantum machine learning, evaluating the complexity of the mappings possible in tractable time.

MATH 859O. Inverse Problems in Partial Differential Equations (3).
A study of basic results in inverse problems for elliptic and parabolic partial differential equations. Goal is to understand and use some existing methods of proving uniqueness, stability and possibly existence (the orthogonality relations, exponential and singular solutions, etc.).

MATH 880. Proseminar (1).
Oral presentation of research in areas of interest to the students. Prerequisite: major standing.

MATH 881. Individual Reading (1-5).
Repeatable up to a maximum of 6 hours with departmental consent. Prerequisite: departmental consent.

MATH 881AB. Applications of Conformal Mapping (3).
Applications of conformal mapping: We will consider applications of conformal mapping to inverse problems.

MATH 881Y. Inverse Problems II (3).

MATH 881Z. Topics in Geometry (3).
Introductory course in geometry. Students learn about various classical geometries in two- and three- dimensions: Euclidean, projective, elliptic and hyperbolic.

MATH 885. Thesis (1-4).
May be repeated to a maximum of 6 hours credit. Prerequisite: departmental consent.

MATH 942. Applied Functional Analysis II (3).
Introduces functional analysis and its applications. Prerequisites: MATH 843, Pre- or corequisite: MATH 755.

MATH 947. Theory Fluid Dynamics I (3).
Mechanics of fluid flow, momentum and energy principles, Navier-Stokes and Euler equations, potential flows, vortex dynamics, stability analysis and numerical methods applied to fluid dynamics. Prerequisite: MATH 745.

MATH 948. Theory Fluid Dynamics II (3).
Mechanics of fluid flow, momentum and energy principles, Navier-Stokes and Euler equations, potential flows, vortex dynamics, stability analysis and numerical methods applied to fluid dynamics. Prerequisite: MATH 745.

MATH 952. Advanced Topics in Numerical Analysis (3).
Advanced topics of current research interest in numerical analysis. Topics chosen at instructor's discretion. Possible areas of concentration are numerical methods in ordinary differential equations, partial
differential equations and linear algebra. Repeatable with departmental consent. Prerequisites: MATH 751, 851, and instructor's consent.

MATH 958. Selected Advanced Topics in Applied Mathematics (3).
Topics of current research interest in applied mathematics. Repeatable for credit with departmental consent. Prerequisite: instructor's consent.

MATH 959. Selected Advanced Topics in Applied Mathematics (3).
Topics of current research interest in applied mathematics. Repeatable for credit with departmental consent. Prerequisite: instructor's consent.

MATH 981. Advanced Independent Study in Applied Mathematics (1-3).
Arranged individual directed study in an area of applied mathematics. Repeatable to a maximum of 6 hours. Prerequisites: must have passed the PhD qualifying exam and instructor's consent.

MATH 985. PhD Dissertation (1-9).
Repeatable to a maximum of 24 hours. Prerequisite: must have passed the PhD preliminary exam.