

# Mathematical and Statistical Sciences

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**Chairperson: Anne Clough, Ph.D.**

Department of Mathematical and Statistical Sciences website (<https://www.marquette.edu/mathematical-and-statistical-sciences/>)

The Department of Mathematical and Statistical Sciences offers a unique learning environment with areas of study ranging from pure and applied mathematics to mathematics education and statistics.

The Mathematics major (MATH) explores the interplay between the pure theory and the practical applications of mathematics. The mathematics curriculum can be tailored to an individual's interests with a focus in pure mathematics, applied mathematics or actuarial science, statistics, as well as secondary education. In any case, the curriculum is designed to provide technical skills for growth within the discipline and for success in a wide variety of careers.

The Computational Mathematics major (COMA) provides an enriching blend of courses in applied mathematics augmented with computer science courses. The Computational Mathematics curriculum develops the computing skills required for many of today's applications.

The Statistical Science major (STSC) targets the growing demand for talented statisticians by integrating mathematical foundations and statistical thinking together with computational proficiency with modern computational statistical tools.

The Mathematics for Elementary School Teachers major (MELT) is for College of Education students who are seeking teaching certification at the elementary school level, while obtaining strong mathematical preparation. This program is designed to prepare "mathematics specialists" who provide vision, focus and leadership in elementary schools.

Data Science is the emerging field that seeks to extract and quantify knowledge from data. The Interdisciplinary Data Science major (INDS) integrates statistics and mathematics with computer science, allowing students to develop the knowledge and skills necessary to discover and quantify new knowledge from data. Those prepared to integrate advanced technology with modern statistical and mathematical practices have the opportunity to use data in action to benefit society. Data scientists turn data into knowledge.

## Accelerated Bachelor's–Master's and Bachelor's– M.B.A. Degree Programs

The Department of Mathematical and Statistical Sciences offers a five-year B.S./M.S. accelerated degree program in which students may obtain both an B.S. degree in a variety of undergraduate majors such as Mathematics, Statistics, Data Science or Economics and a professional master of science (M.S.) degree in Applied Statistics in five years. In addition, together with the Graduate School of Management, the Department of Mathematical and Statistical Sciences offers a five-year B.S./M.B.A. accelerated degree program.

- Computational Mathematics, BS (<https://bulletin.marquette.edu/arts-sciences/mathemematical-statistical-sciences/computational-mathematics-bs/>)
- Mathematics for Elementary School Teachers (MELT), Major (<https://bulletin.marquette.edu/arts-sciences/mathemematical-statistical-sciences/melt-ba/>)
- Mathematics, BS (<https://bulletin.marquette.edu/arts-sciences/mathemematical-statistical-sciences/mathematics-bs/>)
- Mathematics, Minor (<https://bulletin.marquette.edu/arts-sciences/mathemematical-statistical-sciences/mathematics-minor/>)
- Statistical Science, BS (<https://bulletin.marquette.edu/arts-sciences/mathemematical-statistical-sciences/statistical-science-bs/>)

## Graduate Programs

- Applied Statistics, MS (<https://bulletin.marquette.edu/graduate/applied-statistics-ms/>)
- Bioinformatics, MS (<https://bulletin.marquette.edu/graduate/bioinformatics-ms/>)
- Computational Mathematical and Statistical Sciences, MS (<https://bulletin.marquette.edu/graduate/computational-mathematical-statistical-sciences-ms/>)
- Computational Mathematical and Statistical Sciences, PHD (<https://bulletin.marquette.edu/graduate/computational-mathematical-statistical-sciences-phd/>)
- Mathematics for Secondary School Teachers, MS (<https://bulletin.marquette.edu/graduate/mathematics-secondary-school-teachers-ms/>)

### **MATH 1100 College Algebra (3 credits)**

Precalculus mathematics including basic algebraic operations, equations, inequalities, complex numbers, graphs, functions, zeros of polynomials, systems of equations and matrices.

*Prerequisite:* Two years of college preparatory mathematics including a year each of algebra and geometry.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Summer Term, 2021 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201100>)

**MATH 1101 Trigonometry and Analytic Geometry (3 credits)**

A continuation of MATH 1100 covering precalculus mathematics including trigonometric functions and their properties, trigonometric identities and equations, applications of trigonometry, vectors, polar coordinates, exponential and logarithmic functions and conic sections. Equivalent is one year of high school geometry and the equivalent of MATH 1100 in high school courses.

*Prerequisite:* MATH 1100 or equiv.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2001 Spring Term, 2000 Fall Term, 2000 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201101>)

**MATH 1200 Precalculus (3 credits)**

Review of topics from college algebra and trigonometry required for the calculus sequence. Emphasis on understanding functions including polynomials and rational functions, trigonometric functions, and exponential and logarithmic functions.; or cons. of instr.

*Prerequisite:* Two years of college preparatory mathematics including a year each of algebra and geometry; Fr. or Soph. stndg.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201200>)

**MATH 1300 The Nature of Mathematics (3 credits)**

Concepts of mathematics for liberal arts students. Emphasis on understanding and appreciating concepts rather than developing computational skills.

Topics include the historical development of ideas, role of abstraction, and relationship between different areas of mathematics is given precedence over performance of arithmetic and algebraic manipulations.

*Prerequisite:* Two years of college preparatory mathematics.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Basic Needs & Justice, NSM Expanding Our Horizons

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201300>)

**MATH 1390 Finite Mathematics (3 credits)**

Mathematics of finance, including simple and compound interest, present and future value of ordinary annuities, sinking funds, and amortization schedules. Matrices, linear systems and linear programming. Combinatorics and elementary probability theory. Equivalent is three years of college preparatory mathematics.

*Prerequisite:* MATH 1100 or equivalent.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Individuals & Communities

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Summer Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201390>)

**MATH 1400 Elements of Calculus (3 credits)**

The basic concepts and techniques of differential and integral calculus. Applications and examples chosen primarily from economics, biology, the social and behavioral sciences and business. Equivalent is three years of college preparatory mathematics.

*Prerequisite:* MATH 1100 or equiv.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Expanding Our Horizons

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201400>)

**MATH 1401 Elements of Calculus Lab (3 credits)**

Developmental lab for MATH 1400. Learning through active participation with other students in small group settings.

*Prerequisite:* MATH 1400 which must be taken concurrently.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 1995 Spring Term, 1994 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201401>)

**MATH 1410 Calculus for the Biological Sciences (3 credits)**

Fundamental concepts and techniques of differential and integral calculus, logarithmic, exponential and trigonometric functions, examples and applications from biology and medicine. Equivalent is three years of college preparatory mathematics.

*Prerequisite:* MATH 1100 or equivalent.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Basic Needs & Justice

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201410>)

**MATH 1450 Calculus 1 (4 credits)**

Functions of one variable, limits and continuity. The derivative and the definite integral with applications. Equivalent is three to four years of college preparatory mathematics including topics listed in description of MATH 1101.

*Prerequisite:* MATH 1101 or equiv.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Expanding Our Horizons

*Interdisciplinary Studies:* Applied Mathematics Economics, Bioinformatics

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201450>)

**MATH 1451 Integral Calculus (4 credits)**

The transcendental functions. Techniques of integration including numerical methods. Elementary differential equations. Infinite sequences and series, Taylor Series. Not regularly offered.

*Prerequisite:* MATH 1450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Summer Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201451>)

**MATH 1455 Calculus 2 (4 credits)**

Techniques of integration, including numerical methods. Applications of integrals, Taylor polynomials, analytic geometry and vectors. The differential and integral calculus of functions of several variables.

*Prerequisite:* MATH 1450.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201455>)

**MATH 1700 Modern Elementary Statistics (3 credits)**

Fundamental theory and methods of statistics without calculus. Descriptive statistics, elements of probability theory, estimation, tests of hypotheses, regression, correlation, introduction to computer methods of statistical tabulation and analysis. Recommended for students seeking a general introduction to statistical concepts and not intended to be a final course in statistics for students who need a thorough working knowledge of statistical methods. May not be taken for credit by students who have received college credit for another probability or statistics course.

*Prerequisite:* Two years of college preparatory mathematics.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Cgntn, Lang, Mmry/Intlgnc, NSM Crossing Boundaries

*Interdisciplinary Studies:* Cognitive Science, Environmental Studies, International Affairs, Public History

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201700>)

**MATH 1700H Honors Modern Elementary Statistics (3 credits)**

Fundamental theory and methods of statistics without calculus. Descriptive statistics, elements of probability theory, estimation, tests of hypotheses, correlation, regression, ANOVA, introduction to computer methods of statistical tabulation and analysis. Offered with a laboratory component and is recommended for students seeking a general introduction to statistical concepts. Students learn to compute various statistical measures - both with and without the aid of a computer. Not intended to be a final course in statistics for students who need a thorough working knowledge of statistical methods. May not be taken for credit by students who have received college credit for another probability or statistics course. As an Honors Program course, includes a more intensive research or project component.

*Prerequisite:* Two years of college preparatory mathematics; admission to Marquette University Honors Program; and PSYC 1700H, which must be taken concurrently.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Cgntn, Lang, Mmry/Intlgnc, NSM Crossing Boundaries

*Interdisciplinary Studies:* Cognitive Science, Public History

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%201700H>)

**MATH 2030 Problem Solving and Reasoning for Teachers (3 credits)**

Mathematical content and processes. Mathematical techniques and ways of thinking are used to enhance mathematical power. Multiple ways of organizing and analyzing data, reasoning and communication skills, and multiple problem-solving strategies are used to solve non-routine problems. Provides a framework for deepening and expanding elementary mathematical ideas.

*Prerequisite:* Two years of college preparatory mathematics.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Expanding Our Horizons

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202030>)

**MATH 2031 Number Systems and Operations for Elementary Teachers (3 credits)**

Mathematical content and processes for teachers. Uses a problem solving approach. Integrates early mathematics content with teaching methods and learning theory. Provides a framework for in-depth study of number concept, meaning of place value, whole numbers, exponents, fractions, decimals, percent, ratios, and proportions. In-depth study of whole and rational number systems including analyses of algorithmic procedures for addition, subtraction, multiplication and division.

*Prerequisite:* MATH 2030 and enrolled in the elementary teacher preparation program.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202031>)

**MATH 2032 Algebra and Geometry for Teachers (3 credits)**

Mathematical content and processes for elementary and secondary school teachers. Uses a problem solving approach. Integrates mathematics content with teaching methods and learning theory. In-depth study of the growth of algebraic and geometric reasoning. Provides a framework for the meaningful understanding and teaching of integers, patterns, algebraic expressions, functions, equations, graphs, spatial visualization, polygons and polyhedra, similarity and congruence, conjectures and deductions in geometry, and mathematical modeling.

*Prerequisite:* Enrolled in mathematics and secondary education program; or MATH 2031 and enrolled in elementary education.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202032>)

**MATH 2100 Discrete Mathematics (3 credits)**

Introduction to set theory, logic, mathematics induction, finite state machines, graph theory, modular arithmetic, Boolean algebra, and coding theory. Applications in computer science are emphasized. May not be taken for credit by those who have completed MATH 2350.

*Prerequisite:* MATH 1400, MATH 1410 or MATH 1450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Bioinformatics

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202100>)

**MATH 2350 Foundations of Mathematics (3 credits)**

Introduction to set theory, logic, mathematical induction, graph theory, modular arithmetic, and higher mathematical thinking through proof and applications. Mathematical proof is emphasized.

*Prerequisite:* MATH 1400, MATH 1410 or MATH 1450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Bioinformatics

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202350>)

**MATH 2440 Calculus 3 (4 credits)**

Improper integrals, infinite sequences, and series including the Taylor series. Other advanced topics in vector calculus and multivariable calculus such as Lagrange multipliers, Green's Theorem, Divergence Theorem, and Stokes Theorem.

*Prerequisite:* MATH 1455.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202440>)

**MATH 2450 Multivariable Calculus (4 credits)**

Three-dimensional analytic geometry including parametric equations, vectors and vector functions. The differential and integral calculus of functions of several variables.

*Prerequisite:* MATH 1451.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202450>)

**MATH 2451 Differential Equations (4 credits)**

Methods and techniques applicable to first order, nth order, and systems of first order differential equations. Eigenvalues, eigenvectors, the Wronskian, Laplace transforms, linearization and phase portraits.

*Prerequisite:* MATH 1455 or MATH 2450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202451>)

**MATH 2455 Differential Equations for Biomedical and Civil Engineers (3 credits)**

Methods and techniques for solving differential equations and systems of differential equations, with applications to biomedical and civil engineering.

Restricted to students in BIEN or CEEN.

*Prerequisite:* MATH 1455 or MATH 2450.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202455>)

**MATH 2780 Introduction to Regression and Classification (3 credits)**

Basic concepts of supervised learning, simple linear regression, multiple linear regression, diagnostic analysis, model selection, logistic regression, classification and regression trees (CART), random forest and use of statistical software R.

*Prerequisite:* MATH 1700 or an equivalent introductory statistics course.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%202780>)

**MATH 3100 Linear Algebra and Matrix Theory (3 credits)**

N-dimensional vector spaces, bases and coordinate systems, linear transformations and matrices, systems of equations, characteristic values, applications to differential equations and geometry.

*Prerequisite:* MATH 2100, MATH 2350, or MATH 2451.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%203100>)

**MATH 3520 Operational Methods in Physics and Engineering (3 credits)**

Functions of a complex variable. Laplace and Fourier transforms and applications. Introduction to the calculus of variations.

*Prerequisite:* MATH 2450.

*Level of Study:* Undergraduate

*Last four terms offered:* 2007 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%203520>)

**MATH 3570 Introduction to Data Science (3 credits)**

A initial course in visualizing and extracting information from data and models. Topics include introduction to Python or R, clustering, dimension reduction, regression and basis functions. Credit is not given for both COSC 3570 and MATH 3570.

*Prerequisite:* COSC 1010; MATH 2780 or MATH 4710 or MATH 4720, which may be taken concurrently.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%203570>)

**MATH 3700 An Introduction to Modeling with Simulation and Scientific Computing (3 credits)**

Project-based modeling. Focuses on using computational software R and Matlab in mathematics and statistics: plotting, version control, simple/useful data structures and basic data i/o. Topics include population dynamics, SIR models, agent-based models, linear regression, Monte Carlo techniques and principal component analysis.

*Prerequisite:* COSC 1010 and MATH 1450.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%203700>)

**MATH 3977 Problem Solving: Putnam Competition (1 credits)**

Studies mathematical problems, examine their solutions and formulate general problem solving methods and techniques. Prepares students for the Putnam Mathematical Competition. S/U grade assessment.

*Prerequisite:* Cons. of instr.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%203977>)

**MATH 4020 The Teaching of Mathematics (3 credits)**

Historical background, problems, curricular materials, and teaching procedures in the various areas of mathematics pertinent to the needs of a secondary school mathematics teacher. In addition, a three-hour time block on one day each week between 8 a.m. and 3 p.m. must be kept free for clinical experience. Admission to the College of Education.

*Prerequisite:* EDUC 2001; and MATH 4120 or MATH 4420, which may be taken concurrently.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2020 Fall Term, 2018 Fall Term, 2017 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204020>)



**MATH 4030 Concepts in Geometry and Calculus from an Advanced Standpoint (3 credits)**

Topics chosen primarily from geometry and calculus, taught from an advanced standpoint to enrich and deepen the student's understanding. Emphasis on alternative approaches, generalizations, historical contexts and connections with prior mathematical studies.

*Prerequisite:* MATH 4420, and six additional cr. hrs. of upper division MATH courses, and cons. of dept. ch.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Spring Term, 2021 Spring Term, 2019 Spring Term, 2017 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204030>)

**MATH 4040 Concepts in High School Algebra and Number Theory from an Advanced Standpoint (3 credits)**

Topics closely related to the high school mathematics curriculum, chosen primarily from algebra and number theory, taught from an advanced standpoint to enrich and deepen the student's understanding. Emphasis on alternative approaches, generalizations, historical contexts and connections with prior mathematical studies. Course is offered for graduate credit only to students enrolled in MSST.

*Prerequisite:* Admitted to the College of Education.

*Level of Study:* Undergraduate

*Last four terms offered:* 2016 Spring Term, 2014 Spring Term, 2012 Spring Term, 2010 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204040>)

**MATH 4120 Abstract Algebra 1 (3 credits)**

Sets, mappings, operations on sets, relations and partitions. A postulational approach to algebraic systems including semigroups, groups, rings and fields. Homomorphisms of groups and rings, number systems, polynomial rings.

*Prerequisite:* MATH 2100 or MATH 2350.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204120>)

**MATH 4121 Abstract Algebra 2 (3 credits)**

A continuation of MATH 4120 with emphasis on groups, rings, fields and modules.

*Prerequisite:* MATH 4120.

*Level of Study:* Undergraduate

*Last four terms offered:* 2021 Spring Term, 2019 Spring Term, 2017 Spring Term, 2016 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204121>)

**MATH 4200 Intermediate Analysis 1 (3 credits)**

Limits and continuity, differentiability, Riemann integration. Topology of N-dimensional spaces.

*Prerequisite:* MATH 2451 or MATH 3100.

*Level of Study:* Undergraduate

*Last four terms offered:* 2021 Fall Term, 2019 Fall Term, 2017 Fall Term, 2015 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204200>)

**MATH 4201 Intermediate Analysis 2 (3 credits)**

Transformations of N-spaces, line and surface integrals, sequences and series, uniform convergence.

*Prerequisite:* MATH 4200.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204201>)

**MATH 4210 Complex Variables (3 credits)**

Complex numbers, analytic functions, differentiation, series expansion, line integrals, singularities and residues.

*Prerequisite:* MATH 2450.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Spring Term, 2020 Spring Term, 2018 Spring Term, 2016 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204210>)

**MATH 4310 History of Mathematical Ideas (3 credits)**

Topics selected from the following: development of the number system (need for irrational and complex numbers); development of geometry including the effects of the discovery of non-Euclidean geometry; limit concept; need for axiomatic structures; twentieth-century problems. Current mathematics research and place of mathematics in today's world.

*Prerequisite:* Jr. stndg. or cons. of dept. ch.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Spring Term, 2019 Spring Term, 2017 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204310>)

**MATH 4320 Theory of Numbers (3 credits)**

Integers, unique factorization theorems, arithmetic functions, theory of congruences, quadratic residues, partition theory.

*Prerequisite:* MATH 2100 or MATH 2350.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2020 Spring Term, 2018 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204320>)

**MATH 4420 Foundations of Geometry (3 credits)**

Modern postulational development of Euclidean and non-Euclidean geometries.

*Prerequisite:* MATH 2100 or MATH 2350.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204420>)

**MATH 4450 Topology (3 credits)**

Topological spaces, mappings, metric spaces, product and quotient spaces. Separation axioms, compactness, local compactness and connectedness.

*Prerequisite:* MATH 2100 or MATH 2350.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2021 Spring Term, 2019 Spring Term, 2017 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204450>)

**MATH 4500 Theory of Differential Equations (3 credits)**

Existence and uniqueness theorems, linear and non-linear systems, numerical techniques, stability.

*Prerequisite:* MATH 2451, MATH 2455 or MATH 3100.

*Level of Study:* Undergraduate

*Last four terms offered:* 2020 Fall Term, 2018 Fall Term, 2016 Fall Term, 2014 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204500>)

**MATH 4510 Elementary Partial Differential Equations (3 credits)**

Fourier series, method of separation of variables, eigenfunction expansions, application of eigenfunctions to partial differential equations, Green's functions and transform methods.

*Prerequisite:* MATH 2451, MATH 2455 or MATH 3100.

*Level of Study:* Undergraduate

*Last four terms offered:* 2021 Spring Term, 2019 Spring Term, 2017 Spring Term, 2015 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204510>)

**MATH 4540 Numerical Analysis (3 credits)**

Numerical solution of algebraic and transcendental equations, linear systems and the algebraic eigenvalue problem, interpolation and approximation, numerical integration, difference equations, numerical solution of differential equations and finite difference methods.

*Prerequisite:* MATH 1451; and MATH 2451 or MATH 3100; and COSC 1010 or EECE 1610.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204540>)

**MATH 4630 Mathematical Modeling and Analysis (3 credits)**

Construction and analysis of mathematical models from biological, behavioral and physical sciences.

*Prerequisite:* MATH 2451, MATH 2455 or MATH 3100.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Fall Term, 2021 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204630>)

**MATH 4650 Theory of Optimization (3 credits)**

Fundamental theorems describing the solution of linear programs and matrix games. Minimax, duality, saddle point property, simplex and specialized algorithms. Zero sum games, transportation and assignment problems, applications to economics.

*Prerequisite:* MATH 2451, MATH 2455 or MATH 3100.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2021 Spring Term, 2019 Spring Term, 2017 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204650>)

**MATH 4670 Applied Combinatorial Mathematics (3 credits)**

Permutations and combinations, recurrence relations, inclusion and exclusion, Polya's theory of counting, graph theory, transport networks, matching theory.

*Prerequisite:* MATH 2100 or MATH 2350.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Spring Term, 2020 Spring Term, 2018 Spring Term, 2016 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204670>)

**MATH 4700 Theory of Probability (3 credits)**

Random variables, distributions, moment generating functions of random variables, various derived probabilistic models and applications. Recommended, with MATH 4710, for students in mathematics, engineering, and the physical and behavioral sciences.

*Prerequisite:* MATH 2450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics, Cognitive Science

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204700>)

**MATH 4710 Mathematical Statistics (3 credits)**

Sampling theory and distributions, estimation and hypothesis testing, regression, correlation, analysis of variance, non-parametric methods, Bayesian statistics.

*Prerequisite:* MATH 4700.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204710>)

**MATH 4720 Statistical Methods (3 credits)**

Probability, discrete and continuous distributions. Treatment of data, point and interval estimation, hypothesis testing. Large and small sample method, regression, non-parametric methods. An introductory applications-oriented course recommended for students who wish to acquire a basic understanding of statistical methods. May not be taken for credit by those who have completed MATH 4710.

*Prerequisite:* MATH 1400, MATH 1410 or MATH 1450.

*Level of Study:* Undergraduate

*Marquette Core Curriculum:* NSM Expanding Our Horizons

*Interdisciplinary Studies:* Applied Mathematics Economics, Bioinformatics, Cognitive Science, Environmental Studies

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204720>)

**MATH 4730 Introduction to R for Statistics and Data Science (1 credits)**

An introductory course to the statistical analysis software R. Topics include basic R programming, importing and cleaning data, data visualization, performing descriptive and inferential statistics, and creating reproducible reports.

*Prerequisite:* MATH 2780, MATH 4720 or MATH 4740; any of which may be taken concurrently.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204730>)

**MATH 4740 Biostatistical Methods and Models (3 credits)**

Introduction to the statistics of life science and the use of mathematical models in biology. Data analysis and presentation, regression, analysis of variance, correlation, parameter estimation and curve fitting. Biological sequence analysis, discrete and continuous mathematical models and simulation. Credit is not given for both MATH 4720 and MATH 4740.

*Prerequisite:* MATH 1400, MATH 1410 or MATH 1450.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Bioinformatics, Cognitive Science, Environmental Studies

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204740>)

**MATH 4750 Computational Statistics (3 credits)**

Explores computational data analysis, an essential part of modern statistics. Introduces statistical computing including statistical programming, Monte Carlo simulation and parallel computing, smoothing and density estimation, implementing numerical methods in R (e.g., Expectation-Maximization algorithm), fitting models to data, statistical prediction and cross-validation.

*Prerequisite:* COSC 1010; MATH 3100; and MATH 4700 or MATH 4780.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204750>)



**MATH 4760 Time Series Analysis (3 credits)**

Basic concepts of probability. Stationary time series. Autocorrelation and spectrum. Descriptive methods for time series data. ARMA and ARIMA models: estimation and forecasting. Identification and diagnostic techniques. Periodogram and spectral analysis. Use of software for time series analysis.

*Prerequisite:* MATH 2450; and MATH 4720 or equiv.

*Level of Study:* Undergraduate

*Interdisciplinary Studies:* Applied Mathematics Economics

*Last four terms offered:* 2022 Spring Term, 2020 Spring Term, 2018 Spring Term, 2016 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204760>)

**MATH 4770 Statistical Machine Vision (3 credits)**

Object recognition and tracking for automatic machine vision systems. Topics include image representation, convolution, filter design, statistical deconvolution, discrete Fourier transform, automated object identification, text analysis, video object tracking and line tracing. Real-world applications such as object tracking within sequence of images, identification of item placement location in industrial settings, and autonomous lane departure identification. Additional topics may include object feature representations and statistical classification of objects. Computational implementation and examples utilize high-level programming language.

*Prerequisite:* Computer programming such as COSC 1010; introductory calculus such as MATH 1450; and statistical methods such as MATH 4720 or MATH 4740.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204770>)

**MATH 4780 Regression Analysis (3 credits)**

Basic concepts of statistical inference, simple linear regression, multiple linear regression, diagnostic analysis, selecting the best equation, stepwise methods, nonlinear regression and use of statistical software.

*Prerequisite:* MATH 2780 or MATH 4720 or equiv.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204780>)

**MATH 4790 Bayesian Statistics (3 credits)**

Bivariate, conditional and marginal distributions. The Bayesian philosophy, quantification of a priori information, prior, likelihood and posterior distributions. Bayesian linear models, posterior parameter estimation including maximum posteriori and marginal expectations. Topics may include numerical integration and Markov chain Monte Carlo techniques. Use of a high-level software package.; MATH 1450 or equiv.; and MATH 4720 or equiv.

*Prerequisite:* COSC 1010 or equiv.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204790>)

**MATH 4931 Topics in Mathematical or Statistical Sciences (1-3 credits)**

Topics selected from one of the various branches of mathematics or statistics. Specific topics to be announced in the Schedule of Classes.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Summer Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204931>)

**MATH 4953 Undergraduate Seminar (3 credits)**

Designed to initiate a selected group of qualified undergraduates into the techniques and discipline of scholarly research by concentrated work in a restricted field. Emphasis on critical reading and analysis of sources. Specific topics to be announced in the Schedule of Classes.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Undergraduate

*Last four terms offered:* 2007 Fall Term, 1990 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204953>)

**MATH 4987 Co-op Work Period (0 credits)**

Students work full-time during fall or spring terms in a cooperative education program work assignment approved in advance by the department. Responsibilities include relevant academic content. Grading and credits are accomplished by registering for MATH 4988 during the following term. Fee. SNC/UNC grade assessment.

*Prerequisite:* Jr. stndg.

*Level of Study:* Undergraduate

*Last four terms offered:* 2017 Fall Term, 2014 Spring Term, 2012 Spring Term, 2011 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204987>)

**MATH 4988 Co-op Grading Period (1 credits)**

Grading for preceding co-op work assignment is accomplished by completing a report on the work assignment, a report on academic material related to the work assignment, and other materials as required. Grading is completed during the school term following the work assignment. May be taken more than once, but a maximum of two credits may be counted toward a major in the department.

*Prerequisite:* Jr. stndg. and MATH 4987.

*Level of Study:* Undergraduate

*Last four terms offered:* 2018 Spring Term, 2014 Fall Term, 2013 Fall Term, 2012 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204988>)

**MATH 4995 Independent Study in Mathematical or Statistical Sciences (1-3 credits)**

Faculty-supervised, independent study/research of a specific area or topic in in Mathematics or Statistics.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Undergraduate

*Last four terms offered:* 2021 Spring Term, 2020 Spring Term, 2019 Spring Term, 2018 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204995>)

**MATH 4999 Senior Thesis (2 credits)**

Preparation of a thesis by approved students under the direction of an adviser from the staff.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Undergraduate

*Last four terms offered:* 2016 Spring Term, 2015 Fall Term, 2015 Spring Term, 2014 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=MATH%204999>)