

Mathematical and Statistical Sciences

Chairperson: Rebecca Sanders, 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 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.

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, 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.

Major in Mathematics

The major in mathematics consists of 39 credit hours of mathematics courses, including five required MATH courses (18 credit hours); one MATH sequence (two courses - 6 credit hours); at least one course from each of the three groups (Group 1 - Pure Mathematics, Group 2 - Applied Mathematics and Group 3 - Statistics, for a total of 9 credit hours); and 6 additional credit hours of upper division MATH courses.

Note:

- Students majoring in mathematics must also complete the following course in computer science: COSC 1010 Introduction to Software Development.

Required Mathematics Courses:

MATH 1450	Calculus 1	4
MATH 1451	Calculus 2	4
MATH 2350	Foundations of Mathematics	3
MATH 2450	Calculus 3	4
MATH 3100	Linear Algebra and Matrix Theory	3

Choose one of the following sequences: 6

MATH 4120 & MATH 4121	Abstract Algebra 1 and Abstract Algebra 2	
MATH 4200 & MATH 4201	Intermediate Analysis 1 and Intermediate Analysis 2	
MATH 4200 & MATH 4210	Intermediate Analysis 1 and Complex Variables	
MATH 4200 & MATH 4450	Intermediate Analysis 1 and Topology	
MATH 4420 & MATH 4030	Foundations of Geometry and Concepts in Geometry and Calculus from an Advanced Standpoint	
MATH 4500 & MATH 4510	Theory of Differential Equations and Elementary Partial Differential Equations	
MATH 4670 & MATH 4650	Applied Combinatorial Mathematics and Theory of Optimization	

MATH 4700 & MATH 4710	Theory of Probability and Mathematical Statistics		
Choose at least one additional course from each of the three groups listed below:			9
Group 1 - Pure Mathematics			
MATH 4120	Abstract Algebra 1		
MATH 4121	Abstract Algebra 2		
MATH 4200	Intermediate Analysis 1		
MATH 4201	Intermediate Analysis 2		
MATH 4210	Complex Variables		
MATH 4320	Theory of Numbers		
MATH 4420	Foundations of Geometry		
MATH 4450	Topology		
Group 2 - Applied Mathematics			
MATH 3520	Operational Methods in Physics and Engineering		
MATH 4500	Theory of Differential Equations		
MATH 4510	Elementary Partial Differential Equations		
MATH 4540	Numerical Analysis		
MATH 4630	Mathematical Modeling and Analysis		
MATH 4650	Theory of Optimization		
MATH 4670	Applied Combinatorial Mathematics		
Group 3 - Statistics			
MATH 4700	Theory of Probability		
MATH 4710	Mathematical Statistics		
MATH 4720	Statistical Methods		
MATH 4740	Biostatistical Methods and Models		
MATH 4760	Time Series Analysis		
MATH 4780	Regression Analysis		
Choose 6 credit hours of upper-division MATH courses.			6
Total Credit Hours			39

Note:

- Occasionally MATH 4931 Topics in Mathematical or Statistical Sciences may be approved as a substitute within a student's program of study for an above listed course.
- MATH 2350 Foundations of Mathematics is the preferred course for a MATH major. For those seeking a double major in COSC or a minor in COSC, MATH 2100 Discrete Mathematics can be accepted as a substitute.

Typical Program for Mathematics Major

Freshman

First Term	Hours	Second Term	Hours
MATH 1450	4	MATH 1451	4
ENGL 1001 or ESSV1 (MCC)	3	COSC 1010	4
PHIL 1001 or THEO 1001 (MCC)	3	ENGL 1001 or ESSV1 (MCC)	3
Elective	3	PHIL 1001 or THEO 1001 (MCC)	3
		13	14

Sophomore

First Term	Hours	Second Term	Hours
MATH 2350	3	MATH 3100	3
MATH 2450	4	CORE 1929 (MCC) or elective	3
CORE 1929 (MCC) or elective	3	DSCV (MCC) ^{1,2}	3

DSCV (MCC) ^{1,2}	3	Electives	6
Elective	3		
			15

Junior

First Term	Hours	Second Term	Hours
MATH Sequence (Part 1)	3	MATH Sequence (Part 2)	3
MATH Group 1 (Pure)	3	MATH Group 3 (Statistics)	3
DSCV (MCC) ^{1,2}	3	DSCV (MCC) ^{1,2}	3
Electives	6	Electives	6
			15

Senior

First Term	Hours	Second Term	Hours
MATH Group 2 (Applied)	3	MATH 3xxx/4xxx	3
MATH 3xxx/4xxx	3	CORE 4929 (MCC) or elective	3
CORE 4929 (MCC) or elective	3	Electives	10
Electives	7		
			16

Total credit hours: 120

- ¹ The four courses in the Discovery Tier (DSCV) of the MCC must be completed in the same theme and include the following content areas: Humanities (HUM), Social Science (SSC), Natural Science and Mathematics (NSM) and one elective (ELE), which is an additional course from any of the three content areas. A maximum of two courses in the Discovery Tier can apply towards a primary major.
- ² Students must also complete the Writing Intensive (WRIT) and Engaging Social System and Values 2 (ESSV2) requirements of the MCC. These requirements can be fulfilled through designated courses in the Discovery Tier or other degree requirements.

Department of Public Instruction Certification for Mathematics Majors

To pursue Department of Public Instruction certification, College of Education students are required to fulfill the requirements of a mathematics major (39 credit hours of mathematics courses) as listed below. In addition to the 39 credit hours, students must complete an introductory computer science course (4 credit hours), the mathematics teaching methodology course (3 credit hours), and the algebra and geometry course for middle school teachers (2 credit hours) for a total of 48 credit hours as listed below.

Notes:

- Students majoring in mathematics must also complete COSC 1010 Introduction to Software Development
- MATH 4020 The Teaching of Mathematics is required as part of the state certification program and must be completed before student teaching.
- MATH 2032 Algebra and Geometry for Teachers is also required.
- From the beginning of their work toward a degree, students should consult with both the department adviser for Mathematics Education and the Director of Teacher Education in the College of Education about the appropriate sequence of courses.

Required Mathematics Courses:

MATH 1450	Calculus 1	4
MATH 1451	Calculus 2	4
MATH 2350	Foundations of Mathematics	3
MATH 2450	Calculus 3	4
MATH 3100	Linear Algebra and Matrix Theory	3
MATH 4420 & MATH 4030	Foundations of Geometry and Concepts in Geometry and Calculus from an Advanced Standpoint	6

Required Group Courses:

Group 1 - Pure Mathematics		
MATH 4120	Abstract Algebra 1	3

Group 2 - Applied Mathematics

MATH 4630	Mathematical Modeling and Analysis	3
-----------	------------------------------------	---

Group 3 - Statistics

MATH 4720	Statistical Methods	3
-----------	---------------------	---

Additional Mathematics Courses:

MATH 4670	Applied Combinatorial Mathematics	3
-----------	-----------------------------------	---

or MATH 4700 Theory of Probability

MATH 4040	Concepts in High School Algebra and Number Theory from an Advanced Standpoint	3
-----------	---	---

Total Credit Hours		39
--------------------	--	----

Math B.S./M.B.A. Accelerated Degree Program

The Department of Mathematics, Statistics and Computer Science together with the Graduate School of Management offers an accelerated degree program which allows students to earn both their B.S. degree in Math and a master of business administration (M.B.A.) all within in a five-year time period.

During the first four years of the program, students complete both their course work requirements for their Math B.S. degree and the necessary prerequisite courses for the M.B.A. degree in the College of Business Administration. In addition, undergraduate students begin their M.B.A. graduate work in their senior year by taking two graduate level courses.

To be considered for admission to the B.S./M.B.A. five-year program, applicants must formally apply to the Graduate School of Management during their junior year at Marquette University. For more detailed information and details of a typical five-year course work plan, please refer to the Graduate School of Management Bulletin and contact the Department of Math, Statistics and Computer Science or the Graduate School of Management.

Major in Computational Mathematics

The major in computational mathematics consists of 54-55 credit hours of computer science and mathematics courses as listed below:

Required Computer Sciences Courses:

COSC 1010	Introduction to Software Development	4
-----------	--------------------------------------	---

COSC 1020	Object-Oriented Software Design	4
-----------	---------------------------------	---

COSC 2100	Data Structures	3
-----------	-----------------	---

COSC 3100	Algorithms	3
-----------	------------	---

Computer Science Elective: Choose one of the following.		3
---	--	---

COSC 3090 Bioinformatics Algorithms

COSC 3250 Operating Systems

COSC 3410 Programming Languages

COSC 3570 Introduction to Data Science

COSC 3810 Software Design and Analysis

COSC 4600 Fundamentals of Artificial Intelligence

COSC 4610 Data Mining

Required Mathematics Courses:

MATH 1450	Calculus 1	4
-----------	------------	---

MATH 1451	Calculus 2	4
-----------	------------	---

MATH 2350	Foundations of Mathematics	3
-----------	----------------------------	---

MATH 2450	Calculus 3	4
-----------	------------	---

MATH 2451	Differential Equations	4
-----------	------------------------	---

MATH 3100	Linear Algebra and Matrix Theory	3
-----------	----------------------------------	---

MATH 4540	Numerical Analysis	3
-----------	--------------------	---

MATH 4630	Mathematical Modeling and Analysis	3
-----------	------------------------------------	---

MATH 4720	Statistical Methods	3
-----------	---------------------	---

or MATH 4740 Biostatistical Methods and Models

Mathematics Electives: Choose two of the following.		6
---	--	---

MATH 3570 Introduction to Data Science

MATH 4200 Intermediate Analysis 1

MATH 4210 Complex Variables

MATH 4500 Theory of Differential Equations

MATH 4510	Elementary Partial Differential Equations
MATH 4650	Theory of Optimization
MATH 4670	Applied Combinatorial Mathematics
MATH 4700	Theory of Probability
MATH 4710	Mathematical Statistics
MATH 4760	Time Series Analysis
MATH 4780	Regression Analysis
<hr/>	
Total Credit Hours	54

- Note:**
- Depending on course topic and departmental approval, an upper division MATH course outside of list may be substituted as a Mathematics elective.
 - Depending on course topic and departmental approval, an upper division COSC course outside of list may be substituted as a Computer Science elective.

Typical Program for Computational Mathematics Majors

Freshman

First Term	Hours	Second Term	Hours
COSC 1010	4	COSC 1020	4
MATH 1450	4	MATH 1451	4
ENGL 1001 or ESSV1 (MCC)	3	ENGL 1001 or ESSV1 (MCC)	3
PHIL 1001 or THEO 1001 (MCC)	3	PHIL 1001 or THEO 1001 (MCC)	3
<hr/>		<hr/>	
		14	14

Sophomore

First Term	Hours	Second Term	Hours
COSC 2100	3	MATH 2451	4
MATH 2350	3	MATH 3100	3
MATH 2450	4	CORE 1929 (MCC) or elective	3
CORE 1929 (MCC) or elective	3	DSCV (MCC) ^{1,2}	3
Elective	3	Elective	3
<hr/>		<hr/>	
		16	16

Junior

First Term	Hours	Second Term	Hours
MATH 4540	3	COSC 3100	3
MATH 4720 or 4740	3	Mathematics elective	3
DSCV (MCC) ^{1,2}	3	DSCV (MCC) ^{1,2}	3
DSCV (MCC) ^{1,2}	3	DSCV (MCC) ^{1,2}	3
Elective	3	Elective	3
<hr/>		<hr/>	
		15	15

Senior

First Term	Hours	Second Term	Hours
MATH 4630	3	Mathematics elective	3
Computer Science elective	3-4	CORE 4929 (MCC) or elective	3
CORE 4929 (MCC) or elective	3	Electives	9

Electives	6	
	15-16	15

Total credit hours: 120-121

- ¹ The four courses in the Discovery Tier (DSCV) of the MCC must be completed in the same theme and include the following content areas: Humanities (HUM), Social Science (SSC), Natural Science and Mathematics (NSM) and one elective (ELE), which is an additional course from any of the three content areas. A maximum of two courses in the Discovery Tier can apply towards a primary major.
- ² Students must also complete the Writing Intensive (WRIT) and Engaging Social System and Values 2 (ESSV2) requirements of the MCC. These requirements can be fulfilled through designated courses in the Discovery Tier or other degree requirements.

Major in Mathematics for Elementary School Teachers (MELT)

This major is for students in the College of Education enrolled in the middle childhood/early adolescence teacher education program (grades 1-8). The major in mathematics for elementary teachers consists of twelve required mathematics courses for a total of 36 credit hours as listed below.

Note:

- From the beginning of their work toward a degree, students should consult with both a department adviser and the director of teacher education in the College of Education about the appropriate sequence of courses. University and state requirements for teacher certification are described in the College of Education section of this bulletin.

Required Courses:

MATH 1450	Calculus 1	4
MATH 1451	Calculus 2	4
MATH 2030	Problem Solving and Reasoning for Teachers	3
MATH 2031	Number Systems and Operations for Elementary Teachers	2
MATH 2032	Algebra and Geometry for Teachers	2
MATH 2350	Foundations of Mathematics	3
MATH 3100	Linear Algebra and Matrix Theory	3
MATH 4310	History of Mathematical Ideas	3
MATH 4320	Theory of Numbers	3
MATH 4420	Foundations of Geometry	3
MATH 4630	Mathematical Modeling and Analysis	3
MATH 4720	Statistical Methods	3
Total Credit Hours		36

Typical Program for Mathematics for Elementary School Teachers Majors

Freshman

First Term	Hours	Second Term	Hours
ARSC 1020	4	ARSC 1021	4
EDUC 1210	3	EDUC 1220	3
ENGL 1001	3	ENGL 1002 or COMM 1100	3
Second Language 1	4	Second Language 2	4
MATH 1450	4	MATH 1451	4
Service Learning			
		18	18

Sophomore

First Term	Hours	Second Term	Hours
EDUC 2227	3	HIST 1301, 1401, or 1501	3
POSC 2201	3	EDUC 2330	3

Literature elective	3	PHIL 1001	3
MATH 2350	3	MATH 3100	3
HIST 1101	3	MATH 4310 or 4320	3
THEO 1001	3	THEO 2000	3
Field Experience 1			

18 18

Junior

First Term	Hours	Second Term	Hours
PHIL 2310	3	EDUC 4240	3
EDUC 4347	4	EDUC 4317	3
EDUC 4217	3	EDUC 4357	4
EDUC 4337 (must be taken for 3 cr. hrs.)	3	MATH 2031	2
MATH 2030	3	EDUC 1964	1
MATH 4420	3	MATH 4310 or 4320	3
Field Experience 2		MATH 4630	3
		Field Experience 3	

19 19

Senior

First Term	Hours	Second Term	Hours
EDUC 4297	4	EDUC 4966 (must be taken for 15 cr. hrs.)	15
EDUC 4540	3		
EDUC 4964	4		
MATH 2032	2		
EDUC 2964	1		
MATH 4720	3		
Senior Level Practicum			

17 15

Total credit hours: 142

Note:

- A minimum of 120 credits is required for the degree.
- EDUC 4337 Teaching Elementary Social Studies must be taken for 3 cr. hrs.
- EDUC 4966 Student Teaching: Elementary/Middle must be taken for 15 cr. hrs.

Minor in Mathematics

The minor in mathematics consists of 24 credit hours of mathematics courses, including four required math courses (15 credit hours) and an additional 9 credit hours of upper division math courses as listed below.

Required Courses:

MATH 1450	Calculus 1	4
MATH 1451	Calculus 2	4
MATH 2450	Calculus 3	4
MATH 2350 or MATH 2451	Foundations of Mathematics Differential Equations	3

Electives - Choose at least nine additional hours of upper-division MATH courses.

9

Total Credit Hours

24

Department of Public Instruction Certification for Mathematics Minor

To pursue Department of Public Instruction certification for a minor in mathematics, College of Education students are required to fulfill the requirements of the mathematics minor (24 credit hours of mathematics courses) as listed below. In addition to the 24 credit hours in mathematics, students must complete the mathematics teaching methodology course (3 credit hours), as listed below.

Notes:

- MATH 4020 The Teaching of Mathematics is required as part of the state certification program and must be completed before student teaching.
- From the beginning of their work toward a degree, students should consult with both the department adviser for Mathematics Education and the director of Teacher Education in the College of Education about the appropriate sequence of courses.
- MATH 2350 Foundations of Mathematics is the preferred course for a MATH minor. For those seeking a major in COSC or a minor in COSC, MATH 2100 Discrete Mathematics can be substituted.

Required Courses:

MATH 1450	Calculus 1	4
MATH 1451	Calculus 2	4
MATH 2450	Calculus 3	4
MATH 2350	Foundations of Mathematics	3
MATH 3100	Linear Algebra and Matrix Theory	3
MATH 4420	Foundations of Geometry	3
MATH 4720	Statistical Methods	3
Total Credit Hours		24

Courses

MATH 1100. College Algebra. 3 cr. hrs.

Precalculus mathematics including basic algebraic operations, equations, inequalities, complex numbers, graphs, functions, zeros of polynomials, systems of equations and matrices. Prereq: Two years of college preparatory mathematics including a year each of algebra and geometry.

MATH 1101. Trigonometry and Analytic Geometry. 3 cr. hrs.

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. Prereq: MATH 1100 or equiv. Equivalent is one year of high school geometry and the equivalent of MATH 1100 in high school courses.

MATH 1300. The Nature of Mathematics. 3 cr. hrs.

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. Prereq: Two years of college preparatory mathematics.

MATH 1390. Finite Mathematics. 3 cr. hrs.

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. Prereq: MATH 1100 or equivalent. Equivalent is three years of college preparatory mathematics.

MATH 1400. Elements of Calculus. 3 cr. hrs.

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. Prereq: MATH 1100 or equiv. Equivalent is three years of college preparatory mathematics.

MATH 1410. Calculus for the Biological Sciences. 3 cr. hrs.

Fundamental concepts and techniques of differential and integral calculus, logarithmic, exponential and trigonometric functions, examples and applications from biology and medicine. Prereq: MATH 1100 or equivalent. Equivalent is three years of college preparatory mathematics.

MATH 1450. Calculus 1. 4 cr. hrs.

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

MATH 1451. Calculus 2. 4 cr. hrs.

The transcendental functions. Techniques of integration including numerical methods. Elementary differential equations. Infinite sequences and series, Taylor Series. Prereq: MATH 1450.

MATH 1455. Calculus 2 for Biomedical and Civil Engineers. 4 cr. hrs.

Techniques of integration, including numerical methods. Infinite sequences and series, including Taylor Series. Analytic-Geometry including parametric equations, vectors and vector functions. The differential and integral calculus of functions of several variables. Prereq: MATH 1450, declared BIOC, BIOE, BIOM, CIEN or ENEN majors.

MATH 1700. Modern Elementary Statistics. 3 cr. hrs.

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. Prereq: Two years of college preparatory mathematics. May not be taken for credit by students who have received college credit for another probability or statistics course.

MATH 1700H. Honors Modern Elementary Statistics. 4 cr. hrs.

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. Prereq: Two years of college preparatory mathematics; and admission to Marquette University Honors Program.

MATH 2030. Problem Solving and Reasoning for Teachers. 3 cr. hrs.

Mathematical content and processes for teachers. 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 nonroutine problems. In the process, elementary mathematical ideas are expanded and deepened. Restricted to students in the teacher preparation program. Prereq: Two years of college preparatory mathematics.

MATH 2031. Number Systems and Operations for Elementary Teachers. 2 cr. hrs.

Mathematical content and processes for elementary teachers. Uses a problem solving approach. Integrates mathematics content with teaching methods and learning theory. In-depth study of whole and rational number systems including analyses of algorithms for addition, subtraction, multiplication, and division. Provides a framework for the meaningful teaching of place value, whole numbers, exponents, fractions, decimals, percents, ratios, proportions, probability and data analysis. Prereq: EDUC 1964, which must be taken concurrently; MATH 2030 and enrolled in the elementary teacher preparation program.

MATH 2032. Algebra and Geometry for Teachers. 2 cr. hrs.

Mathematical content and processes for 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 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. Prereq: EDUC 2964, which must be taken concurrently; MATH 2031 and Elementary Education students.

MATH 2100. Discrete Mathematics. 3 cr. hrs.

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. Prereq: MATH 1400, MATH 1410 or MATH 1450.

MATH 2350. Foundations of Mathematics. 3 cr. hrs.

Introduction to set theory, logic, mathematical induction, graph theory, modular arithmetic, and higher mathematical thinking through proof and applications. Mathematical proof is emphasized. Prereq: MATH 1400, MATH 1410 or MATH 1450.

MATH 2450. Calculus 3. 4 cr. hrs.

Three-dimensional analytic geometry including parametric equations, vectors and vector functions. The differential and integral calculus of functions of several variables. Prereq: MATH 1451.

MATH 2451. Differential Equations. 4 cr. hrs.

Methods and techniques applicable to first order, n th order, and systems of first order differential equations. Eigenvalues, eigenvectors, the Wronskian, Laplace transforms, linearization and phase portraits. Prereq: MATH 1455 or MATH 2450.

MATH 2455. Differential Equations for Biomedical and Civil Engineers. 3 cr. hrs.

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. Prereq: MATH 1455 or MATH 2450.

MATH 3100. Linear Algebra and Matrix Theory. 3 cr. hrs.

N -dimensional vector spaces, bases and coordinate systems, linear transformations and matrices, systems of equations, characteristic values, applications to differential equations and geometry. Prereq: MATH 2100, MATH 2350, or MATH 2451.

MATH 3520. Operational Methods in Physics and Engineering. 3 cr. hrs.

Functions of a complex variable. Laplace and Fourier transforms and applications. Introduction to the calculus of variations. Prereq: MATH 2450.

MATH 3570. Introduction to Data Science. 3 cr. hrs.

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. Prereq: COSC 1010; MATH 1450; MATH 4710 or MATH 4720, which may be taken concurrently. Credit is not given for both COSC 3570 and MATH 3570.

MATH 3977. Problem Solving: Putnam Competition. 1 cr. hr.

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. Prereq: Cons. of instr.

MATH 4020. The Teaching of Mathematics. 3 cr. hrs.

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. Prereq: EDUC 2227; and MATH 4120 or MATH 4420, which may be taken concurrently. Admission to the College of Education.

MATH 4030. Concepts in Geometry and Calculus from an Advanced Standpoint. 3 cr. hrs.

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

MATH 4040. Concepts in High School Algebra and Number Theory from an Advanced Standpoint. 3 cr. hrs.

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. Prereq: MATH 4120. Admitted to the College of Education.

MATH 4120. Abstract Algebra 1. 3 cr. hrs.

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. Prereq: MATH 2100 or MATH 2350.

MATH 4121. Abstract Algebra 2. 3 cr. hrs.

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

MATH 4200. Intermediate Analysis 1. 3 cr. hrs.

Limits and continuity, differentiability, Riemann integration. Topology of N-dimensional spaces. Prereq: MATH 2451 or MATH 3100.

MATH 4201. Intermediate Analysis 2. 3 cr. hrs.

Transformations of N-spaces, line and surface integrals, sequences and series, uniform convergence. Prereq: MATH 4200.

MATH 4210. Complex Variables. 3 cr. hrs.

Complex numbers, analytic functions, differentiation, series expansion, line integrals, singularities and residues. Prereq: MATH 2450.

MATH 4310. History of Mathematical Ideas. 3 cr. hrs.

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. Prereq: Jr. stndg. or cons. of dept. ch.

MATH 4320. Theory of Numbers. 3 cr. hrs.

Integers, unique factorization theorems, arithmetic functions, theory of congruences, quadratic residues, partition theory. Prereq: MATH 2100 or MATH 2350.

MATH 4420. Foundations of Geometry. 3 cr. hrs.

Modern postulational development of Euclidean and non-Euclidean geometries. Prereq: MATH 2100 or MATH 2350.

MATH 4450. Topology. 3 cr. hrs.

Topological spaces, mappings, metric spaces, product and quotient spaces. Separation axioms, compactness, local compactness and connectedness. Prereq: MATH 2100 or MATH 2350.

MATH 4500. Theory of Differential Equations. 3 cr. hrs.

Existence and uniqueness theorems, linear and non-linear systems, numerical techniques, stability. Prereq: MATH 2451, MATH 2455 or MATH 3100.

MATH 4510. Elementary Partial Differential Equations. 3 cr. hrs.

Fourier series, method of separation of variables, eigenfunction expansions, application of eigenfunctions to partial differential equations, Green's functions and transform methods. Prereq: MATH 2451, MATH 2455 or MATH 3100.

MATH 4540. Numerical Analysis. 3 cr. hrs.

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

MATH 4630. Mathematical Modeling and Analysis. 3 cr. hrs.

Construction and analysis of mathematical models from biological, behavioral and physical sciences. Prereq: MATH 2451, MATH 2455 or MATH 3100.

MATH 4650. Theory of Optimization. 3 cr. hrs.

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. Prereq: MATH 2451, MATH 2455 or MATH 3100.

MATH 4670. Applied Combinatorial Mathematics. 3 cr. hrs.

Permutations and combinations, recurrence relations, inclusion and exclusion, Polya's theory of counting, graph theory, transport networks, matching theory. Prereq: MATH 2100 or MATH 2350.

MATH 4700. Theory of Probability. 3 cr. hrs.

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. Prereq: MATH 2450.

MATH 4710. Mathematical Statistics. 3 cr. hrs.

Sampling theory and distributions, estimation and hypothesis testing, regression, correlation, analysis of variance, non-parametric methods, Bayesian statistics. Prereq: MATH 4700.

MATH 4720. Statistical Methods. 3 cr. hrs.

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. Prereq: MATH 1400, MATH 1410 or MATH 1450. May not be taken for credit by those who have completed MATH 4710.

MATH 4740. Biostatistical Methods and Models. 3 cr. hrs.

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. Prereq: MATH 1400, MATH 1410 or MATH 1450. Credit is not given for both MATH 4720 and MATH 4740.

MATH 4760. Time Series Analysis. 3 cr. hrs.

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. Prereq: MATH 2450.

MATH 4780. Regression Analysis. 3 cr. hrs.

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. Prereq: MATH 4720 or equiv.

MATH 4931. Topics in Mathematical or Statistical Sciences. 1-3 cr. hrs.

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

MATH 4953. Undergraduate Seminar. 3 cr. hrs.

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. Prereq: Cons. of dept. ch.

MATH 4987. Co-op Work Period. 0 cr. hrs.

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. Prereq: Jr. stndg.

MATH 4988. Co-op Grading Period. 1 cr. hr.

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. Prereq: Jr. stndg. and MATH 4987.

MATH 4995. Independent Study in Mathematics. 1-3 cr. hrs.

Directed reading and/or research in Mathematics under a member of the staff. Prereq: Cons. of dept. ch.

MATH 4999. Senior Thesis. 2 cr. hrs.

Preparation of a thesis by approved students under the direction of an adviser from the staff. Prereq: Cons. of dept. ch.