

# MATHEMATICS

Mathematics is one of the most precise and versatile human languages.

With it, mathematical scientists have described and understood complex physical phenomena, supported the infrastructure of the internet era, optimized production in industrial processes, and cultivated the creativity of young minds. As a language, together with its axiomatic underpinnings, mathematics is also a much-explored structure in itself. In recent decades, the boundary between pure and applied mathematics has dissolved, and training in both is important for every mathematician. The 21st century, with its growing importance of big data and computation, offers many opportunities to mathematicians.

The Department of Mathematics and Statistics offers a B.A. / B.S. degree in Mathematics, minors in Mathematics or in Computer and Computational Mathematics and a certificate in Mathematics for Finance. Mathematics Education courses are also available.

## Mathematics and Applied and Computational Mathematics 4+1 Option

The Accelerated Masters Studies Option (4+1 Option) in Mathematics and Applied and Computational Mathematics (MATH-ACM) is designed to allow motivated students to earn both a B.A. or B.S. in Mathematics and an M.S. in Applied and Computational Mathematics with one additional year of coursework. This is achieved by a double-counting allowance of up to 13 credits or four graduate level (500-level or above) courses. One additional year of graduate work (17 credits) would be needed to complete the Master's program enabling students to earn two degrees in a total of five years.

The courses double counted must be elected at the 500 level and include:

### Required:

- Math 551 (Advanced Calculus)
- Math 562 (Math Modeling)
- Math 572 (Numerical Analysis)

This satisfies the major requirement for MATH 451 and the two electives for the A.B. or B.S. and all of the Core requirements for the M.S. degree.

And **either** Option I or II:

- **Option I:** MATH 554 for the Core Elective in the major.
- **Option II:** One 500-level STAT class for the Cognate.

The M.S. degree is completed by selecting 3 courses in appropriate Modeling Specialization areas, two masters level cognates, and completing a Masters Project.

- **A student may not receive credit for both a 400 and 500 level equivalent courses (for example, both Math 455 and Math 555).**

Please see the Applied and Computational Mathematics 4+1 Option (<https://umdearborn.edu/casl/graduate-programs/programs/master-science-applied-and-computational-mathematics/applied-and-computational-mathematics-41-option/>) webpage for additional information.

In addition to the major requirements, students must complete all CASL Degree Requirements (<http://catalog.umd.umich.edu/undergraduate/college-arts-sciences-letters/>).

## Prerequisites to the Major

Students desiring to major in mathematics are required to have successfully completed:

Code	Title	Credit Hours
MATH 115	Calculus I	4
MATH 116	Calculus II	4
MATH 215	Calculus III	4
MATH 227	Introduction to Linear Algebra	3
MATH 228	Diff Eqns with Linear Algebra	4
Select one of the following:		3-4
CIS/CCM 150	Computer Science I	
CIS 1501	CS I for Data Scientists	
STAT 327	Statistical Computing	
ENGR 216	Computer Meth for Engineers	
<b>Total Credit Hours</b>		<b>22-23</b>

## Major Requirements

A total of at least 32 credit hours of coursework must be elected in the major and cognate areas at the upper level (300-400 level courses). Students are required to elect at least 26 hours of coursework in the mathematics major including:

Code	Title	Credit Hours
<b>Required Courses</b>		
MATH 300	Math Lang Proof & Struct	3
MATH 412	Introduction to Modern Algebra	4
MATH 451	Advanced Calculus I	4
<b>Probability/Statistics - Select one of the following:</b>		<b>3-4</b>
MATH 325	Probability	
STAT 325	Applied Statistics I	
STAT 327	Statistical Computing	
<b>Core Elective - Select one of the following:</b>		<b>3</b>
MATH 331	Survey of Geometry	
MATH 395	Elementary Number Theory	
MATH 454	Fourier Series and Boundary Value Problems	
MATH 455	Func of a Complex Var with App	
<b>Capstone - Select one of the following:</b>		<b>3</b>
MATH 492	Introduction to Topology	
MATH 4000	Capstone in Mathematics	
<b>Electives - Select two courses from the following:</b>		<b>6</b>
MATH 325	Probability	
MATH 331	Survey of Geometry	
MATH 390	Topics in Mathematics	
MATH 395	Elementary Number Theory	
MATH 396	Introduction to Cryptography	
MATH 420	Stochastic Processes	
MATH 423	Applied Linear Algebra	

MATH 425	Mathematical Statistics
MATH 454	Fourier Series and Boundary Value Problems
MATH 455	Func of a Complex Var with App
MATH 458	Introduction to Wavelets
MATH 462	Mathematical Modeling
MATH 472	Introduction to Numerical Analysis
<b>Cognates</b>	
Select 6 credits upper level (300/400 and 3000/4000) from the following:	6
CCM	
CHEM (including CHEM 225 and CHEM 226) <sup>1</sup>	
CIS (including CIS 200 and CIS 290) <sup>1</sup>	
ECE	
ECON 305	Economic Statistics
ECON 4015	Introduction to Econometrics
IMSE (except IMSE 334) <sup>3</sup>	
ME	
PHIL 350	Symbolic Logic <sup>2</sup>
PHIL/STS 485 Philosophy of Science	
PHYS	
STAT (Only one of STAT 301, STAT 325 can be used to satisfy this requirement) <sup>3</sup>	
<b>Total Credit Hours</b>	<b>32-33</b>

<sup>1</sup> Courses joined with “and” count together as **one course**.

<sup>2</sup> Cannot receive credit for both PHIL 234 and PHIL 350. PHIL 234 cannot be used in Cognates.

<sup>3</sup> Cannot receive credit for both Stat 325 and IMSE 317.

#### Notes:

- Courses listed in more than one place can only count toward one of the requirements. For example, a student who elects Stat 325 in the probability/statistics requirement must elect another course for a cognate. A student who elects Math 455 in the core elective, must elect another course in the electives.
- STAT 301 cannot be used in place of STAT 325 in the probability/statistics requirement in the major.
- Students who wish to use graduate-level courses, numbered 500 or higher, as part of the 26 credit hours of upper-level MATH coursework required for the major, must submit a Petition to obtain the approval of the faculty Program Advisor in Mathematics.
- Students seeking secondary teacher certification must take MATH 331, MATH 486, EDD 450 and EDD 451. Also, MATH 395 and a course in statistics (STAT) are recommended for such students. None of the following MATH courses may be used to fulfill any requirements of either a Mathematics major or a Mathematics minor: MATH 381, MATH 382, MATH 383, MATH 384, MATH 385, MATH 386, MATH 387, MATH 442, MATH 443, MATH 444, MATH 445, MATH 446, MATH 449, MATH 486.
- Applied Statistics courses (STAT) cannot be used to fulfill the Math minor/concentration requirements.
- At least 12 of the 26 upper level credit hours in the mathematics major must be elected at UM-Dearborn in order to graduate.
- In order to enroll in a mathematics class, a student must have earned a grade of at least C- in all prerequisite mathematics courses; a grade

below C- signals that the student should *immediately repeat* the class in order to build a stronger foundation for subsequent study. The same principle applies when a mathematics course is a prerequisite for courses of other disciplines.

8. Students admitted to the 4+1 Option may substitute a maximum of 13 credits from the following: MATH 520 for MATH 420, MATH 523 for MATH 423, MATH 525 for MATH 425, MATH 551 for MATH 451, MATH 554 for MATH 454, MATH 558 for MATH 458, MATH 562 for MATH 462, MATH 572 for MATH 472, STAT 530 for STAT 430, STAT 545 for STAT 445, STAT 560 for STAT 460

## Credit by Examination

The department grants credit for Calculus I to those students who have received a score of three, four, or five on the AB Exam or a score of three on the BC Exam of the Advanced Placement Program Tests of the College Entrance Examination Board. Credit is granted for both Calculus I and Calculus II to those students who have received a score of four or five on the BC Exam of the Advanced Placement Program Tests. In each case, the student is then eligible to elect the next calculus course in the calculus sequence.

## Minor or Integrative Studies Concentration Requirements

A minor or concentration consists of 12 credit hours in mathematics (MATH) courses approved for upper-level credit in the mathematics major. (Excluding MATH 385, 386, 387, 391, 442, 443, 444, 445, 446, 447, 449, 486).

- A minimum GPA of 2.0 is required for the minor/concentration. The GPA is based on all coursework required within the minor (excluding prerequisites).
- A minimum of 9 credits must be completed at UM-Dearborn for a 12 credit minor/concentration.
- A minimum of 12 credits must be completed at UM-Dearborn for a 15 or more credit minor/concentration.
- Courses within a minor/concentration cannot be taken as Pass/Fail (P/F)
- Only 3 credit hours of independent study or internship may be used to fulfill the requirements for a 12 credit hour minor/concentration. Only 6 credit hours of such credit may be used in a 15 or more credit hour minor/concentration.
- Minors requiring 12 credits may share one course with a major. Minors requiring 15 credits or more may share two courses with a major. This does not apply to concentrations for the Integrative Studies major.

## Learning Goals

1. Increase students' command of problem-solving tools and facility in using problem-solving strategies, through classroom exposure and through experience with problems within and outside mathematics.

Problem-solving tools include:

- the ability to reason*
- the ability to make connections*
- an understanding of mathematical structure.*
- Problem-solving strategies are numerous and, in some cases, specific to particular subject areas or to certain levels of mathematics courses.*

2. Increase students' ability to communicate and work cooperatively.

*Communication in mathematics includes the ability to express mathematical ideas both orally and in writing, as well as to read written presentations of mathematics with understanding. The ability to work cooperatively is fostered by experience in working to solve problems or complete projects as a part of a team.*

3. Increase students' ability to use technology and to learn from the use of technology, including improving their ability to make calculations and appropriate decisions about the type of calculations to make.

*Using technology includes experience in using computer mathematics software. Skill in dealing with calculations includes such issues as distinguishing between approximate and exact answers, and determining bounds on error for approximate answers.*

4. Increase students' knowledge of the history and nature of mathematics. Provide students with an understanding of how mathematics is done and learned so that students become self-reliant learners and effective users of mathematics.

*Knowledge of the history and nature of mathematics includes an awareness of how and why mathematics was invented throughout human history and continues to be in our own time. An understanding of how mathematics is done and learned is a crucial part of the development of any student of mathematics, affecting the attitude that the individual brings to the application of mathematics or to the independent learning of new mathematics.*

#### **MATH 080 Introductory Algebra 3 Credit Hours**

The Developmental Mathematics sequence (MATH 080, MATH 090) is offered as a service to students who need extra preparation in mathematics. MATH 080 is for students who are likely to need two semesters of additional preparation in mathematical computation and symbol manipulation, communication, and conceptual understanding. Topics in the two-course sequence include: arithmetic readiness, real numbers and expressions, linear equations and inequalities, lines and functions, systems of linear equations, rational expressions and equations, radicals and complex numbers, quadratic equations and functions, function operations and inverses. Students are required to have Internet-ready devices available for each class meeting. Skill development takes place online and outside scheduled class meetings. The course is graded on an A, B, C, NC (not completed) basis. This course is offered for additive credit.

**Prerequisite(s):** Mathematics Placement with a score of 080

#### **MATH 090 Intermediate Algebra 3 Credit Hours**

The Developmental Mathematics sequence (MATH 080, MATH 090) is offered as a service to students who need extra preparation in mathematics. MATH 090 is for students who (1) have successfully completed MATH 080 or (2) are likely to require only one semester of additional preparation in mathematical computation and symbol manipulation, communication, and conceptual understanding. Topics in the two-course sequence include: arithmetic readiness, real numbers and expressions, linear equations and inequalities, lines and functions, systems of linear equations, rational expressions and equations, radicals and complex numbers, quadratic equations and functions, function operations and inverses. Students are required to have Internet-ready devices available for each class meeting. Skill development takes place online and outside scheduled class meetings. The course is graded on an A, B, C, NC (not completed) basis. This course is offered for additive credit. (F, W).

**Prerequisite(s):** MATH 080 or Mathematics Placement with a score of 090

#### **MATH 104 College Algebra 4 Credit Hours**

The primary purpose of this course is to prepare students for success in MATH 113. Topics include equations and inequalities; linear, quadratic, polynomial, rational, logarithmic and exponential functions along with their graphs and applications; and systems of linear inequalities. This course does not cover trigonometric functions and cannot be used as a prerequisite for MATH 115. Students electing this course should have at least taken two years of High School Algebra and one year of High School Geometry or MATH 090. Students cannot receive credit for both MATH 104 and MATH 105. (F, W, S).

**Prerequisite(s):** MATH 090 or Mathematics Placement with a score of 105

#### **MATH 1040 College Algebra with Studio 4 Credit Hours**

The primary purpose of this course is to prepare students for success in MATH 113. Topics include equations and inequalities; linear, quadratic, polynomial, rational, logarithmic and exponential functions along with their graphs and applications; and systems of linear inequalities. This course does not cover trigonometric functions and cannot be used as a prerequisite for MATH 115. Students electing this course should have at least taken two years of High School Algebra and one year of High School Geometry or MATH 090. This course must be elected together with Math 1041: College Algebra Studio. Students can receive credit for only one of MATH 1040, MATH 104, and MATH 105. (F, W).

**Prerequisite(s):** MATH 090 or Mathematics Placement with a score of 090

**Corequisite(s):** MATH 1041

#### **MATH 1041 College Algebra Studio 1 Credit Hour**

This course provides corequisite support for the companion class MATH 104. By covering intermediate algebra topics in a just-in-time format, students will be better positioned for success in their Math 104 course. Topics include: number sense and basic operations, proportional reasoning, exponential and radical expressions, functions, systems of equations, and transformations on graphs. Students who elect MATH 1041 should also elect MATH 104. A math placement score of at least MATH 90 is required. (F, W).

**Prerequisite(s):** Mathematics Placement with a score of 090

**MATH 1045 Trigonometry 2 Credit Hours**

The primary purpose of this course is to prepare students to take Math 115 (Calculus I) after successfully completing MATH 104 (College Algebra). It also meets students' demand to refresh or enhance their Trigonometry knowledge. Topics to be covered include: Trigonometric Functions, Acute Angles and Right Triangles, Radian Measure and the Unit Circle, Trigonometric identities, Inverse Circular Functions and basics of Functions. (YR)

**Prerequisite(s):** MATH 104

**MATH 105 Pre-Calculus 4 Credit Hours**

Primary purpose of this course is to prepare students for success in Calculus. Topics include equations and inequalities; linear, quadratic, polynomial, rational, logarithmic, exponential and trigonometric functions along with their graphs; application of these functions. Students electing this course should have taken at least two years of High School Algebra and one year of High School Geometry or MATH 090. Students cannot receive credit for both MATH 104 and MATH 105. (F,W,S)

**Prerequisite(s):** MATH 090 or Mathematics Placement with a score of 105

**MATH 113 Calc I for Biology & Life Sci 4 Credit Hours**

This course develops basic concepts of Calculus from the perspectives of Biology and Life Sciences. Topics include differential and integral calculus of algebraic/logarithmic/exponential functions of one variable, limits, continuity, differentiation, integration, graphing, optimization, related rates and area. Applications include modeling biological problems of medicine, genetics, Biomechanics, ecology, population growth and decay. (This course does not fulfill the calculus requirements for concentration in chemistry, physics, biochemistry, engineering, or mathematics) Student cannot receive credit for both Math 113 and Math 115.

**Prerequisite(s):** MATH 105 or MATH 104 or MATH 1040 or Mathematics Placement with a score of 115

**MATH 114 Calc II for Biology & Life Sci 4 Credit Hours**

The topics of this course include advanced methods of integration (integration by parts, partial fraction), modeling with differential equations, some elementary differential equations, matrix algebra, systems of linear equations using matrix method, introduction to probability, conditional probability, discrete and continuous random variables (exponential and normal random variables). Problems in biology, medicine and physiology are used to illustrate how computation and mathematics can improve and enhance the understanding of these problems. Students cannot receive credit for both Math 114 and Math 116.

**Prerequisite(s):** MATH 113 or MATH 115 or Mathematics Placement with a score of 116

**MATH 115 Calculus I 4 Credit Hours**

Calculus is the study of change and accumulation in continuously variable quantities. This course covers limits and continuity, derivatives and their applications, and integrals, with algebraic, exponential, and trigonometric functions and their inverses. Students cannot receive credit for both MATH 113 and MATH 115. (F, S, W)

**Prerequisite(s):** MATH 105 or (MATH 104 and MATH 1045) or Mathematics Placement with a score of 115

**MATH 1151 Calculus I Studio 1 Credit Hour**

This course provides corequisite support for the companion class MATH 115. By covering precalculus topics in a just-in-time format, students will be better positioned for success in their Math 115 course. Topics include: review of functions and their graphs, review of key algebra and trigonometry skills associated with calculus, and practice with key topics in calculus including limits, differentiation, and integration and their applications. Students who elect MATH 1151 should also elect MATH 115. (F, W).

**MATH 116 Calculus II 4 Credit Hours**

This course continues the study of Calculus from Math 115, including applications and techniques of integration, improper integrals, parametric equations, polar coordinates, and sequences and series, including Taylor series. Students cannot receive credit for both MATH 114 and MATH 116. (F, S, W).

**Prerequisite(s):** MATH 115 or Mathematics Placement with a score of 116

**MATH 131 Conceptual Mathematics 4 Credit Hours**

The purpose of Math 131 is to develop an awareness of the use of mathematics in the world around us. Students are encouraged to understand organizational tools of mathematics, including set theory and the use of deductive logic. Areas of application may include: consumer Mathematics, Probability, Statistics, social decision making, apportionment, graph theory, and mathematical modeling. Students intending to elect this course should have taken the equivalent of one year of high school algebra and one year of high school geometry. This course is not open to mathematics concentrators. (F,W,S).

**MATH 205 Calc III for Engin Students 3 Credit Hours**

Vectors in the plane and space, topics from multivariable calculus including partial differentiation and multiple integration, with an emphasis on applications, and line integrals and Green's theorem. This course includes computer labs. Students cannot receive credit for both MATH 205 and MATH 215. (F,W,S).

**Prerequisite(s):** MATH 116 or Mathematics Placement with a score of 215

**MATH 215 Calculus III 4 Credit Hours**

Vectors in the plane and space, vector-valued functions and curves, functions of several variables including limits, continuity, partial differentiation and the chain rule, multiple integrals and coordinate transformations, integration in vector fields, and Green's and Stokes' theorems. This course includes computer labs. Students cannot receive credit for both MATH 205 and MATH 215. (F, W, S).

**Prerequisite(s):** MATH 116 or Mathematics Placement with a score of 215

**MATH 227 Introduction to Linear Algebra 3 Credit Hours**

An introduction to the theory and methods of linear algebra with matrices. Topics include: systems of linear equations, algebra of matrices, matrix factorizations, vector spaces, linear transformations, eigenvalues and eigenvectors, science and engineering applications, and computational methods. Students cannot receive credit for both MATH 227 and MATH 217. (F,W,S).

**Prerequisite(s):** MATH 116 or Mathematics Placement with a score of 215

**MATH 228 Diff Eqns with Linear Algebra 4 Credit Hours**

Full Title: Differential Equations with Linear Algebra This course provides an introduction to ordinary differential equations. Emphasis is placed on the development of abstract concepts and applications for first-order and linear higher-order differential equations, systems of differential equations, introductory numerical methods, matrix algebra, and Laplace transform techniques. It is recommended that students complete MATH 215 or MATH 205 before enrolling in this course. Students cannot receive credits for both MATH 228 and MATH 216 and MATH 217 (F, S, W).

**Prerequisite(s):** MATH 116

**MATH 276 Discrete Math Meth Compr Engr 4 Credit Hours**

An introduction to fundamental concepts of discrete mathematics for computer engineering. Topics will be chosen from: set theory, partially ordered sets, lattices, Boolean algebra, semi-groups, rings, graphical representation of algebraic systems, graphs and directed graphs. Applications in various areas of computer engineering will be discussed. (F,W,S).

**Prerequisite(s):** MATH 116 or Mathematics Placement with a score of 215

**MATH 300 Math Lang Proof & Struct 3 Credit Hours**

A required course for students completing a Mathematics concentration, this course is also a prerequisite for many upper-level Mathematics courses. The course focuses on developing the following: an understanding of, and facility with, the logic and syntax of mathematical statements; and ability to recognize and propose appropriate strategies and outlines for proving given statements; facility in writing mathematical proofs; a knowledge base/toolbox of foundational material including basic concepts and terminology related to naïve set theory.

**Prerequisite(s):** MATH 217 or MATH 227

**MATH 325 Probability 3 Credit Hours**

Brief overview of summary and display of data, probability concepts, discrete and continuous random variables and associated probability models, expectation, independent random variables, probability generating functions and moment generating functions, sampling distributions, the central limit theorem, the t-distribution, properties of estimators, and interval estimation. Previously taught as Mathematical Statistics I. (F).

**Prerequisite(s):** MATH 114 or MATH 116

**MATH 331 Survey of Geometry 3 Credit Hours**

A development of Euclidean geometry as a formal axiom system and an introduction to non-Euclidean geometries and to Transformational Geometry. Geometric models and the history of geometry are stressed. Development of students' geometric intuition as well as their ability to work in a formal axiom system are emphasized. (F).

**Prerequisite(s):** MATH 116 and (MATH 200 or MATH 300)

**MATH 335 Mathematical Interest Theory 3 Credit Hours**

This course will cover introductory topics in the mathematical theory of interest with a focus on types of interest rates, annuities, bonds and loans. These topics will be studied deterministically by applying of a variety of finite and infinite sum formulae. Theoretical derivations of topics, including duration, portfolio immunization and interest rate swaps will be studied. Financial derivatives and stochastic methods will be introduced. Students cannot receive credit for both Math 335 and IMSE 421. (YR)

**Prerequisite(s):** MATH 116

**MATH 381 Mathematics for Elementary Teachers 1: Attribution, Geometry, and Measurement 3 Credit Hours**

This inquiry-based laboratory course intends to support the learning of elementary educators (birth to grade 6) in foundations of attribute concepts; including sorting, comparing, and representing 2D and 3D objects; early geometry concepts; and measurement. The course integrates these areas of mathematical content with pedagogy, including creating mathematical learning environments, selecting worthwhile mathematical tasks, attending to and reacting to others' mathematical thinking, and supporting caregivers in fostering their child's success in mathematics. (W, YR).

**MATH 382 Mathematics for Elementary Teachers 2: Early Number Concepts 3 Credit Hours**

This inquiry-based laboratory course intends to support the learning of early childhood educators (birth to grade 3) in foundations of number concepts; including counting, quantity comparison, number systems and place value, and early fraction concepts. The course integrates these areas of mathematical content with pedagogy, including creating mathematical learning environments, selecting worthwhile mathematical tasks, attending and reacting to others' mathematical thinking, and supporting caregivers in fostering their child's success in mathematics. (F, YR).

**MATH 383 Mathematics for Teachers III: Whole Numbers and Operations 3 Credit Hours**

This course is designed to provide future teachers with opportunities to develop the mathematical understandings crucial to the teaching of whole numbers and operations concepts in the elementary grades. The students will study mathematical ideas including composing and decomposing whole numbers, different meanings and representations for operations, reasoning behind multiple solution strategies and representations, and connections among those solutions and representations. The course integrates mathematical content with pedagogy, including creating inclusive mathematical learning environments, selecting worthwhile mathematical tasks, attending and reacting to others' mathematical thinking, and supporting caregivers in fostering their child's success in mathematics. (F).

**Prerequisite(s):** MATH 381

**MATH 384 Mathematics for Teachers IV: Fractions and Operations 3 Credit Hours**

This course is designed to provide future teachers with opportunities to develop the mathematical understandings crucial to the teaching of fractions and operations concepts in the elementary grades. The students will study mathematical ideas including composing, decomposing, and renaming fractions and decimals, different meanings and representations for fractions and decimals, reasoning behind multiple solution strategies and representations for fraction computation problems, connections among those solutions and representations, and developing solution strategies for solving proportional situations. The course integrates mathematical content with pedagogy, including creating inclusive mathematical learning environments, selecting worthwhile mathematical tasks, attending and reacting to others' mathematical thinking, and supporting caregivers in fostering their child's success in mathematics. (W).

**Prerequisite(s):** MATH 383

**MATH 385 Math for Elemen Teachers I 3 Credit Hours**

The purpose of this course and the Math 386 and Math 387 courses is to provide future teachers with foundational knowledge of mathematics they will teach. An inquiry approach is emphasized involving problem solving, problem posing, pattern seeking, reasoning, justification, representations, and communications. Topics in Math 385 include numeration, meaning of operations, the reasoning behind procedures, and the rational number system, including fractions and decimals. (F,W)

**Restriction(s):**

Can enroll if College is Education, Health, and Human Services

**MATH 386 Math for Elem Teachers II 3 Credit Hours**

The purpose of this course and the Math 385 and Math 387 courses is to provide future teachers with foundational knowledge of mathematics they will teach. An inquiry approach is emphasized involving problem solving, problem posing, pattern seeking, reasoning, justification, representations, and communications. Topics in Math 386 include number theory, proportional reasoning, the geometry of two-dimensional shape and measurement, integers, and the real number system. (F,W)

**Prerequisite(s):** MATH 385

**Restriction(s):**

Can enroll if College is Education, Health, and Human Services

**MATH 387 Math for Elem Teachers III 3 Credit Hours**

The purpose of this course and the Math 385 and Math 386 courses is to provide future teachers with foundational knowledge of mathematics they will teach. An inquiry approach is emphasized involving problem solving, problem posing, pattern seeking, reasoning, justification, representations, and communications. Topics in Math 387 include data analysis; probability; the geometry of three-dimensions including shape, spatial visualization, and measurement; geometric concepts of similarity and congruence; coordinate geometry; and transformational geometry. Algebraic reasoning is integrated throughout. (F,W)

**Prerequisite(s):** MATH 386

**Restriction(s):**

Can enroll if College is Education, Health, and Human Services

**MATH 390 Topics in Mathematics 1 to 3 Credit Hours**

A course designed to offer selected topics in different areas of mathematics. The specific topic or topics will be announced together with the prerequisites each term. Course may be repeated for credit when specific topics differ.

**MATH 390E Topics in Mathematics 3 Credit Hours**

TOPIC TITLE: Preparation for Industrial Careers PIC Math prepares mathematical science students for industrial careers by engaging them in research problems that come directly from industry. A strong component of PIC Math involves students working as a group on a semester-long undergraduate research problem from business, industry, or government. Undergraduate research is a high impact teaching and learning practice and has been shown to improve students abilities in Problem solving. Critical thinking, Independent thinking, and Communicating.

**Prerequisite(s):** MATH 200 or MATH 205 or MATH 215 or MATH 216 or MATH 217 or MATH 227 or MATH 276

**MATH 391 Topics in Mathematics Edu 1 to 3 Credit Hours**

A course designed to offer selected topics in mathematics related to K-12 education. The specific topic or topics will be announced together with the prerequisites each term. Course may be repeated for credit when specific topics differ. (OC).

**MATH 391B Topics in Mathematics and Stat 1 to 3 Credit Hours**

Topic: Number and Proportional Reasoning in Middle School Mathematics Teachers. This course is designed to deepen the teachers of middle school mathematics understanding of the rational number system and its extension to the real number system in a way that models appropriate pedagogy and raises curriculum issues relevant to teaching number concepts for conceptual understanding and computation fluency. A particular emphasis will be on understanding and applying concepts of proportional reasoning. Topics related to this emphasis include analyzing connections between fraction concepts and ratios and proportions; describing the relationship between proportions and direct and indirect variation; analyzing and applying the connections between proportions and similar figures, probability and sampling; and modeling and solving problems involving ratios and proportions. Other major topics include analyzing number theoretic concepts such as prime numbers and divisibility; and comparing and contrasting models of operations across number systems. Calculator and computer technology will be used as problem solving tools and for support in conceptual understanding. Curriculum resources and materials that support conceptual understanding are considered.

**MATH 395 Elementary Number Theory 3 Credit Hours**

Properties of the integers, the division algorithm, Euclid's algorithm, Fermat's theorems, unique factorization of integers into primes, congruences, arithmetic functions, Diophantine equations, continued fractions, quadratic reciprocity. (W).

**Prerequisite(s):** MATH 205 or MATH 215 or MATH 216 or MATH 217 or MATH 227 or MATH 228 or MATH 276

**MATH 396 Introduction to Cryptography 3 Credit Hours**

This course discusses ways of encrypting information, a function which is vital to economics, defense and the empowerment of society. It is more crucial now than ever before to be able to securely transfer information in this age of electronic communication. After discussing primitive ways of encrypting information and explaining the need for more sophisticated encoding methods, this course explores the mathematics (number theory, finite fields and probability) behind both historic and more recent cryptosystems that have been developed for the secure transmission of data along non secure channels. This course continues with symmetric and public key cryptosystems, elliptic curves, digital signatures, zero knowledge protocols and other more advanced methods. This course does not assume any prior knowledge of number theory or probability. (YR)

**Prerequisite(s):** MATH 205 or MATH 215 or MATH 216 or MATH 217 or MATH 227 or MATH 228 or MATH 276

**MATH 399 Independent Studies in Math 1 to 3 Credit Hours**

Independent study in mathematics for topics at the junior level. Topics and objectives chosen by agreement between student and instructor.

**MATH 4000 Capstone in Mathematics 3 Credit Hours**

Math 4000 is the Capstone course in Mathematics, covering an advanced topic in Mathematics determined by the instructor. Topics may include, but are not limited to, algebraic geometry, functional analysis, functions of several complex variables, and aspects of the study of numerical analysis, partial differential equations, combinatorics, probability, number theory, or topology. Students are expected to complete a research project in the area of the particular topic. (W).

**Prerequisite(s):** MATH 227

**Restriction(s):**

Can enroll if Class is Junior or Senior

**MATH 404 Dynamical Systems 3 Credit Hours**

This course is an introduction to nonlinear dynamics and chaos with applications taken from engineering and the sciences. Topics include: one dimensional flows and bifurcations, two dimensional linear systems, phase plane analysis, limit cycles, and bifurcations. The class will finish with an introduction to chaotic systems and, if time permits, a study of fractals and strange attractors. Students cannot receive credit for both MATH 404 and MATH 504. (AY).

**Prerequisite(s):** MATH 228

**MATH 412 Introduction to Modern Algebra 4 Credit Hours**

This course covers an introduction to group theory, ring theory and field theory. Topics in group theory include subgroups, group homomorphisms, factor groups, isomorphism theorems, simple groups, cyclic groups, dihedral groups and permutation groups. Topics in ring theory include ideals, integral domains, Euclidean domains, principal ideal domains, unique factorization domains, and modules. Topics in field theory include field extensions, Kronecker's theorem, and Galois Theory. Students cannot receive credit for both MATH 412 and MATH 512. (W).

**Prerequisite(s):** MATH 300 and MATH 227

**MATH 413 Linear Algebra 3 Credit Hours**

Vector spaces, linear transformations and matrices, determinants, inner product spaces, bilinear and quadratic forms, Hamilton-Cayley theorem, eigenvalues and eigenvectors, and spectral theorem. Students cannot receive credit for both MATH 413 and MATH 513. (F)

**Prerequisite(s):** MATH 300 and (MATH 217 or MATH 227)

**MATH 420 Stochastic Processes 3 Credit Hours**

Review of distribution theory. Introduction to stochastic processes, Markov chains and Markov processes, counting, and Poisson and Gaussian processes. Students cannot receive credit for both MATH 420 and MATH 520. (OC).

**Prerequisite(s):** MATH 325 or STAT 325 or IMSE 317 or ME 364

**MATH 423 Applied Linear Algebra 3 Credit Hours**

Review of elementary linear algebra concepts followed by the study of Gaussian elimination and solutions of systems of equations, matrix factorizations, inverses, vector spaces and subspaces, linear transformations, determinants, eigenspaces and eigen analysis, singular value decomposition. Applications may include discrete Fourier analysis, optimization, solutions of systems of differential equations and data science. Students cannot receive credit for both MATH 423 and MATH 523. (AY).

**Prerequisite(s):** MATH 228 and MATH 227

**MATH 425 Mathematical Statistics 3 Credit Hours**

Interval estimation and pivotal quantities, maximum likelihood estimation, hypothesis tests, linear models and analysis of variance, bivariate normal distribution, regression and correlation analysis, and nonparametric methods. Students cannot receive credit for both MATH 425 and MATH 525. Previously taught as Mathematical Statistics II. (W).

**Prerequisite(s):** MATH 325 or STAT 325

**MATH 435 Mathematics of Finance 3 Credit Hours**

Full Course Title: Introduction to Mathematics of Finance This course teaches students to apply mathematical skills in finance. Topics covered include different types of interests, cash flows, present and future values, yield, probability, annuities, debts, stocks and bonds. (YR)

**Prerequisite(s):** MATH 325

**MATH 442 Geometry for Teachers 3 Credit Hours**

Properties of two and three-dimensional figures are covered, including congruence, symmetry, transformation, and measurement. Trigonometry from a geometric perspective and the use of trigonometry in problem solving are included. Topics also include coordinate geometry and visualization as well as the nature of axiomatic reasoning and the role it has played in the development of mathematics. An investigative approach involving problem solving, reasoning and proof, connections, and communication will be emphasized. Calculator and computer technology will support the investigation of these topics. Classroom resources and materials are considered. Different levels of geometric thinking will be explored. No credit for CASL concentration, minor, or area of focus. Open only to certified teachers or elementary education students. Student cannot receive credit for both MATH 442 and MATH 542.

**Prerequisite(s):** MATH 387

**Restriction(s):**

Cannot enroll if Level is

Can enroll if College is Education, Health, and Human Services

**MATH 443 Algebra for Teachers 3 Credit Hours**

Algebraic structure is emphasized, especially as it relates to arithmetic. Emphasis is on the development of algebraic reasoning and generalizations with the appropriate pedagogy. Curriculum issues relevant to teaching algebra for conceptual understanding are included. Major topics include algebraic representations of linear, exponential, power and quadratic patterns, systems of equations, and applications. An investigative approach involving problem solving, reasoning and proof, connections and communications will be emphasized. Classroom resources and materials are considered as well as calculators and computer technology as problem-solving tools to aid in algebraic thinking. No credit for CASL concentration, minor or area of focus. Students cannot receive credit for both MATH 443 and MATH 543. (F, W, S).

**Prerequisite(s):** MATH 386

**Restriction(s):**

Cannot enroll if Level is

Can enroll if College is Education, Health, and Human Services

**MATH 444 Data Anlsys, Prob&Stat for Tchrs 3 Credit Hours**

Concepts of probability using both experimental and theoretical models are considered with an emphasis on the use of probability models to describe physical phenomena and to make and interpret predictions. Topics in data analysis and statistics include drawing inferences from visual displays of data, applying techniques of inferential statistics, sampling and simulations to generate solutions to problems, and making appropriate inferences using best fit techniques. Evaluating data and arguments to establish validity, interpreting, calculating and solving problems related to correlation, distributions, percentiles and standard scores are also included. An investigative approach involving problem solving, reasoning and proof, connections, and communication will be emphasized. Calculator and computer technology will support the investigation of these topics. No credit for CASL concentration, minor, or area of focus. Open only to certified teachers or elementary education students. Student cannot receive credit for both MATH 444 and MATH 544.

**Prerequisite(s):** MATH 387

**Restriction(s):**

Cannot enroll if Class is

Cannot enroll if Level is

Can enroll if College is Education, Health, and Human Services

**MATH 445 Number & Prop'l Rsnng for Tchrs 3 Credit Hours**

This course deepens previous work on rational number ideas and applications, and explores the concepts of ratio and proportion. Content includes a variety of situations involving proportions, for example, real-world problems involving ratios, rates, and percents, geometry involving similarity, algebra involving linearity, probability involving assigning a probability to an event, and trigonometry involving slope. Distinguishing proportional situations from those that are not and reasoning proportionally in appropriate situations are emphasized. The course includes problem solving, reasoning and proof, connections, communication, and multiple representations. No credit for CASL concentration, minor, or area of focus. Open only to certified teachers or elementary education students or by permission of instructor. Students cannot receive credit for both MATH 445 and MATH 545. (AY).

**Prerequisite(s):** MATH 442 and MATH 443

**Restriction(s):**

Cannot enroll if Class is

**MATH 446 Discrete Math/Modeling for Tch 3 Credit Hours**

This course interweaves the ideas of discrete mathematics with the approaches and strategies of mathematical modeling. It gives pre- and inservice teachers opportunities to deepen their understanding and use of mathematical models based on the concepts of discrete mathematics. Topics include recurrence, induction, permutations, combinations, binomial distributions, circuits, critical paths, minimal spanning trees, adjacency matrices, algorithm design and optimization. Systems thinking and multiple representations are emphasized. No credit for CASL concentration, minor, or area of focus. Open only to certified teachers or elementary education students. Students cannot receive credit for both MATH 446 and 546. (AY).

**Prerequisite(s):** MATH 442 and MATH 443

**Restriction(s):**

Cannot enroll if Class is

Cannot enroll if Level is

**MATH 449 Concepts of Calc for Teachers 3 Credit Hours**

Concepts of Calculus for Teachers focuses on calculus concepts appropriate for middle school mathematics teachers and teacher-candidates. The course provides a deep understanding of the major concepts of calculus: rates of change, accumulation (net change), area, and limits. Students will experience concrete approaches to the various topics using problem solving, manipulatives and technology as appropriate, with the intent being to help the learners discover how the ideas of calculus are useful in a variety of settings. Visual, numeric and commonsense approaches are used. No credit for CASL concentration, minor, or area of focus. Open only to certified teachers or elementary education students. Students cannot receive credit for both MATH 449 and 549. (AY)

**Prerequisite(s):** MATH 442 and MATH 443

**Restriction(s):**

Cannot enroll if Class is

**MATH 451 Advanced Calculus I 4 Credit Hours**

Topics for this course include properties of the real number system, point set theory for the real line and the Bolzano-Weierstrass theorem, sequences, functions of one variable, limits and continuity, differentiability, continuous nowhere-differentiable functions, Riemann integrability, Lebesgue's criterion for Riemann integrability, and series of functions. Students cannot receive credit for both MATH 451 and MATH 551. (F).

**Prerequisite(s):** MATH 300 and MATH 228 and MATH 227

**MATH 452 Advanced Calculus II 3 Credit Hours**

Includes the rigorous study of functions of two and more variables, partial differentiation and multiple integration. Special topics include: Taylor Series, Implicit Function Theorem, Weierstrass Approximation Theorem, Arzela-Ascoli Theorem. Students cannot receive credit for both MATH 452 and MATH 552. (AY,W).

**Prerequisite(s):** MATH 451

**MATH 454 Fourier Series and Boundary Value Problems 3 Credit Hours**

Fourier series and integrals. Their use in solving boundary value problems of mathematical physics by the method of separation of variables. Sturm-Liouville theory and generalized Fourier series, including those involving Bessel functions and Legendre polynomials, with applications. Students cannot receive credit for both MATH 454 and MATH 554. (F).

**Prerequisite(s):** MATH 228 and MATH 215

**MATH 455 Func of a Complex Var with App 3 Credit Hours**

Complex number system. Functions of a complex variable, their derivatives and integrals. Taylor and Laurent series expansions. Residue theory and applications, elementary functions, conformal mapping, and applications to physical problems. Students cannot receive credit for both MATH 455 and MATH 555. (W).

**Prerequisite(s):** (MATH 216 or MATH 228) and (MATH 205 or MATH 215)

**Restriction(s):**

Can enroll if Level is Undergraduate

**MATH 458 Introduction to Wavelets 3 Credit Hours**

This course will introduce the students to theory and application of wavelets using linear algebra. Topics will include the discrete Fourier transform, the fast Fourier transform, linear transformations, orthogonal decomposition, discrete wavelet analysis, the filter bank, Haar Wavelet family, Daubechies's Wavelet family, and applications. Students cannot receive credit for both MATH 458 and MATH 558. (OC)

**Prerequisite(s):** MATH 217 or MATH 227

**Restriction(s):**

Can enroll if Class is Sophomore or Junior or Senior

**MATH 462 Mathematical Modeling 3 Credit Hours**

The processes of constructing, implementing, and evaluating mathematical models of "real world" phenomena are investigated. Models involving continuous and discrete mathematical constructs are considered. Deterministic and stochastic models are compared. Examples are taken from genetics, epidemiology, queuing theory, and other fields. Students cannot receive credit for both MATH 462 and MATH 562. (F).

**Prerequisite(s):** (MATH 205 or MATH 215) and ((MATH 228) or (MATH 216 and MATH 227) or (MATH 216 and MATH 217))

**MATH 472 Introduction to Numerical Analysis 3 Credit Hours**

This course is an introduction to numerical analysis and scientific computing. Topics include: floating point representation, round off error, root finding techniques, interpolation, numerical integration, Gaussian elimination and techniques for solving linear systems, minimizing functions, and methods for solving ordinary differential equations numerically. Students cannot receive credit for both MATH 472 and MATH 572. (F).

**Prerequisite(s):** MATH 227 or MATH 228



**MATH 473 Matrix Computation 3 Credit Hours**

A study of the most effective methods for finding the numerical solution of problems which can be expressed in terms of matrices, including simultaneous linear equations, orthogonal projections and least squares, eigenvalues and eigenvectors, positive definite matrices, and difference and differential equations. Students cannot receive credit for both MATH 473 and MATH 573. (AY, W).

**Prerequisite(s):** MATH 217 or MATH 227

**MATH 486 Sec School Math for Teachers 3 Credit Hours**

Basic concepts, relationships, generalizations, and applications from the secondary school mathematics curriculum are discussed both from an advanced viewpoint and from the standpoint of the learner. Included are the roles of technology, problem solving, and current thinking on the teaching of secondary mathematics topics. Students cannot receive credit for both MATH 486 and MATH 586. (F).

**Prerequisite(s):** MATH 217 or MATH 227

**MATH 492 Introduction to Topology 3 Credit Hours**

Metric spaces, topological spaces, continuous maps, connectedness, compactness, separation axioms. Students cannot receive credit for both MATH 492 and MATH 592. Prior experience in a proof based course is recommended. (OC).

**Prerequisite(s):** MATH 300

**MATH 499 Independent Studies in Math 1 to 3 Credit Hours**

Independent study in mathematics for topics at the senior level. Topics and objectives chosen by agreement between student and instructor. (OC).

\*An asterisk denotes that a course may be taken concurrently.

## Frequency of Offering

The following abbreviations are used to denote the frequency of offering: (F) fall term; (W) winter term; (S) summer term; (F, W) fall and winter terms; (YR) once a year; (AY) alternating years; (OC) offered occasionally