Department of Mathematics
The Ohio State University

2021-2022 Undergraduate Math Courses by Term

This booklet contains detailed descriptions of most Mathematics courses 5000 level and below, including the higher level Honors and Actuarial courses.

For information on courses not listed at 5000-level and below, contact the Math Advising Office 614-292-6994, courses 6000-level and above, contact the Math Graduate Office 614-292-6274.

The course syllabi contained in this booklet may also be found online in PDF format on the course web pages of the math department's website at http://math.osu.edu/courses.

Course Number	Course Title	Credit Hours	Au	Sp	Su
1050	Precollege Mathematics I	5.0	Au	Sp	
1060	Supplementary Pre-College Mathematics	2.0	Au		
1075	Precollege Mathematics II	4.0	Au	Sp	Su
1116	Excursions in Mathematics	3.0	Au	Sp	Su
1118	Mathematics for Architects	3.0	Au	Sp	
1120	Precalculus with Review I	5.0	Au		
1121	Precalculus with Review II	5.0		Sp	
1125	Mathematics for Elementary Teachers I	5.0	Au	Sp	
1126	Mathematics for Elementary Teachers II	5.0	Au	Sp	
1130	College Algebra for Business	4.0	Au	Sp	
1131	Calculus for Business	5.0	Au	Sp	
*1135	Number and Operations for Teachers	5.0	Au	Sp	
*1136	Measurement and Geometry for Teachers	5.0	Au	Sp	
1140	Calculus with Review I	4.0	Au		
1141	Calculus with Review II	4.0		Sp	
1148	College Algebra	4.0	Au	Sp	Su
1149	Trigonometry	3.0	Au	Sp	Su
1150	Pre-Calculus	5.0	Au	Sp	
1151	Calculus I	5.0	Au	Sp	Su
1152	Calculus II	5.0	Au	Sp	Su
1154*	Calculus I for Engineering Technology	4.0	Au		
1155*	Calculus II for Engineering Technology	4.0		Sp	
1156	Calculus for the Biological Sciences	5.0	Au		
1157	Mathematical Modeling for the Biological Sciences	5.0		Sp	
1161.01(^{R})	Accelerated Calculus I				

Course Number	Course Title	Credit Hours	Au	Sp	Su
1161.02(R)	Accelerated Calculus I for Honors Engineers	5.0			
1165	Math for Middle School Teachers I	5.0	Au		
1166	Math for Middle School Teachers II	5.0		Sp	
1172	Engineering Mathematics A	5.0	Au	Sp	Su
1181H	Honors Calculus I	5.0	Au		
1187	Problem Solving	1.0	Au		
1187H	Honors Problem Solving	1.0	Au		
1193#	Individual Studies in Mathematics	1.0			
1194#	Group Studies in Mathematics	1.0			
1194H#	Honors Group Studies in Mathematics	1.0			
1295#	Introductory Seminar	1.0	Au	Sp	
*2137	Algebra and Coordinate Geometry for Teachers	3.0	Au	Sp	
*2138	Calculus and its History for Teachers	3.0	Au	Sp	
2153	Calculus III	4.0	Au	Sp	Su
2162.01(R)	Accelerated Calculus II	5.0			
2162.02(R)	Accelerated Calculus II for Honors Engineers	5.0			
2167	Calculus for Middle School Teachers	3.0	Au		
2168	History of Mathematics for Middle School Teachers	3.0		Sp	
2173	Engineering Mathematics B	3.0	Au	Sp	
2174	Linear Algebra & Differ. Equations for Engineers	3.0	Au	Sp	
2177	Mathematical Topics for Engineers	4.0	Au	Sp	
2182H	Honors Calculus II	5.0		Sp	
2191.01#	Field Experience	2.0			
2191.02#	Field Experience	0.0			
2193#	Individual Studies in Mathematics	1.0			
2194#	Group Studies in Mathematics	1.0			
2255	Differential Equations and Their Applications	3.0	Au	Sp	Su
2366	Introduction to Discrete Mathematics	2.0		Sp	
2415	Ordinary and Partial Differential Equations	3.0	Au	Sp	Su
2566^	Discrete Mathematical Structures	3.0			
2568	Linear Algebra	3.0	Au	Sp	Su
3295#	Senior Seminar	1.0			
3345	Foundations of Higher Mathematics	3.0	Au	Sp	
3350	Introduction to Mathematical Biology	3.0		Sp	
3532	Mathematical Foundations of Actuarial Science	3.0		Sp	
3588	Practicum in Actuarial Science	3.0		Sp	
3589	Introduction to Financial Mathematics	3.0	Au	Sp	Su
3607	Beginning Scientific Computing	3.0	Au	Sp	
3618	Theory of Interest	3.0	Au	Sp	Su

Course Number	Course Title	Credit Hours	Au	Sp	Su
4181H	Honors Analysis I	5.0	Au		
4182H	Honors Analysis II	5.0		Sp	
4193#	Individual Studies in Mathematics	1.0			
4194#	Group Studies in Mathematics	1.0			
4350	Quantitative Neuroscience	3.0		Sp	
4407^	Geometry for Teaching	2.0		Sp	
4480^	Algebra for Teaching	2.0	Au		
4504	History of Mathematics	3.0		Sp	
4507	Geometry	3.0	Au		
4512	Partial Differential Equations for Science & Eng.	3.0	Au	Sp	Su
4530	Probability	3.0	Au	Sp	Su
4544	Transition Introductory Analysis	3.0			
4545	Analysis Overview	4.0	Au		
4547	Introductory Analysis I	3.0	Au	Sp	
4548	Introductory Analysis II	3.0	Au	Sp	
4551	Vector Analysis	3.0	Au	Sp	
4552	Complex Analysis	3.0		Sp	Su
4556	Dynamical Systems	3.0	Au		
4557	Partial Differential Equations	3.0	Au	Sp	
4568	Linear Algebra for Engineering Graduate Students	3.0	Au	Sp	Su
4570	Applied Algebraic Topology	3.0		Sp	
4573	Elementary Number Theory	3.0		Sp^{O}	
4575	Combinatorial Mathematics	3.0		Sp^{E}	
4578	Discrete Mathematical Models	4.0		Sp	
4580	Abstract Algebra I	3.0	Au	Sp	
4581	Abstract Algebra II	3.0	Au	Sp	
5520H	Honors Linear Algebra and Differential Equations	5.0	Au		
5522H	Honors Complex Analysis	5.0		Sp	
5529H	Honors Combinatorics	5.0	Au^{E}		
5530H	Honors Probability	5.0		Sp^{O}	
5540H	Honors Differential Geometry	5.0		Sp^{E}	
5576H	Honors Number Theory	5.0	Au^{O}		
5590H	Honors Abstract Algebra I	5.0	Au		
5591H	Honors Abstract Algebra II	5.0		Sp	
5601^	Essentials of Numerical Methods	3.0	Au		
5602^	Computational Partial Differential Equations	3.0		Sp	
5603^	Numerical Linear Algebra	3.0	Au		
5630	Life Contingencies I	3.0	Au		
5631	Life Contingencies II	3.0		Sp	

Course Number	Course Title	Credit Hours	Au	Sp	Su
5632	Financial Economics for Actuaries	3.0	Au	Sp	Su
5633	Loss Models I	3.0	Au		
5634	Loss Models II	3.0		Sp	
5651^	Mathematical Modeling of Biological Processes	3.0		Sp	
5660^	Integrated Molecular & Cellular Biol for Non-Biologists	3.0		Sp	
5702^	Curves Surfaces in Euclidean Three Space	3.0	Au		
5756	Mathematical Methods in Relativity Theory I	3.0	Au^{E}		
5757	Mathematical Methods in Relativity Theory II	3.0		Sp^{O}	
5801^	General Topology and Knot Theory	3.0		Sp^{E}	

Note:

1. Courses denoted with an (*) are taught at OSU regional campuses.
2. Courses denoted with a (#) are individual studies, group studies, or seminar.
3. Courses denoted with a (^) do not have the course descriptions included in this booklet.
4. Semesters denoted with an (^{O}) indicated this course is offered only odd numbered years.
5. Semesters denoted with an (^{E}) indicated this course is offered only even numbered years.
6. Courses denoted with an (^{R}) have been retired for 2021-2022.

Catalog Description:
Fractions and decimals, basic algebra, graphing lines, factoring, systems of equations. Credit for this course will not count toward graduation in any degree program.

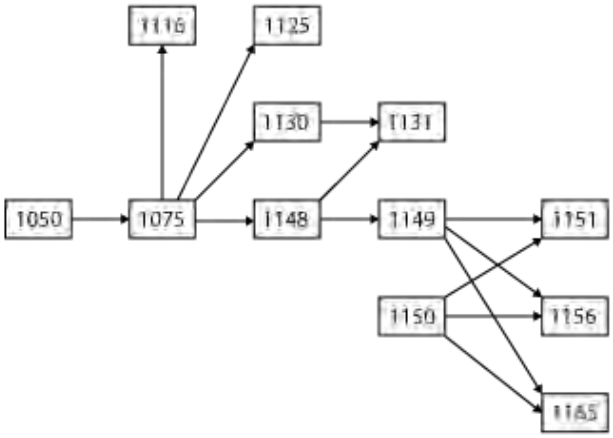
Prerequisite:
Math Placement Level T; or Math 1040 or 40 or 50; or permission of department.

Exclusions:
Not open to students with credit for any Math course above 1050 (050).

Purpose of Course:
Mathematics 1050 is designed to meet the needs of the students entering The Ohio State University at the lowest placement, course code T. This course will prepare students for Math 1075.

Follow-up Course:
Math 1075

Sequencing Chart:



Text:
Beginning Algebra, 8th edition, by Aufmann & Lockwood, Cengage, ISBN: 9781305942653

Topics List:

1.1 Introduction to Integers
1.2 Operations with Integers
1.3 Rational Numbers
App.1 Addition of Fractions using Least Common Denominator
1.4 Exponents and the Order of Operations
1.5 Concepts from Geometry
2.1 Evaluating Variable Expressions
2.2 Simplifying Variable Expressions
2.3 Translating Verbal Expressions into Variable Expressions
3.1 Introduction to Equations
3.2 Applications of Equations of the Form $ax = b$
3.3 General Equations
3.4 Inequalities
Midterm 1
4.1 Translating Sentences into Equations
App.2 Integer, Coins, and Stamps Problems
4.2 Geometry Problems
4.3 Markup and Discount Problems
4.4 Investment Problems
4.5 Mixture Problems
4.6 Uniform Motion Problems
4.7 Inequalities
5.1 The Rectangular Coordinate System
5.2 Graphs of Straight Lines
Midterm 2
5.3 Slopes of Straight Lines
5.4 Equations of Straight Lines
5.6 Graphing Linear Inequalities
6.1 Solving Systems of Linear Equations by Graphing
6.2 Solving Systems of Linear Equations by the Substitution Method
6.3 Solving Systems of Linear Equations by the Addition Method
6.4 Application Problems in Two Variables
7.1 Addition and Subtraction of Polynomials
7.2 Multiplication of Monomials
7.3 Multiplication of Polynomials
7.4 Integer Exponents and Scientific Notation
7.5 Division of Polynomials
Midterm 3
8.1 Common Factors
8.2 Factoring Polynomials of the Form $x^2 + bx + c$
8.3 Factoring Polynomials of the Form $ax^2 + bx + c$
8.4 Special Factoring
8.5 Factoring Polynomials Completely
8.6 Solving Equations
Final

Catalog Description: Rational and radical expressions and equations, quadratic equations; applications.

Prerequisite: Math placement level S or C- or better in Math 1050

Exclusions: Not open to students with credit for any higher numbered math course, or for any quarter math class numbered 50 or higher.

Purpose of Course: This course is only for students intending to take no further mathematics, with the possible exception of Math 1116. In particular, students intending to take Math 1075 should not take this course.

Follow-up Courses:
Terminal course or Math 1116

Text:
Beginning Algebra, 8th edition, by by Aufmann & Lockwood, (Cengage)
ISBN 9781285101279

Topics:

9.1 Multiplication and Division of Rational Expressions
9.2 Expressing Fractions in Terms of the LCD
9.3 Addition and Subtractions of Rational Expressions
9.4 Complex Fractions
9.5 Equations Containing Fractions
9.6 Variation
9.7 Applied Problems

Midterm 1

10.1 Introduction to Radical Expressions
10.2 Addition and Subtraction of Radical Expressions
10.3 Multiplication and Division of Radical Expressions
10.4 Solving Problems Containing Radical Expressions

Midterm 2

11.1 Solving Quadratic Equations by Factoring or Taking Square Roots
11.2 Solving Quadratic Equations by Completing the Square
11.3 Solving Quadratic Equations Using the Quadratic Formula
11.4 Complex Numbers
11.5 Applied Problems

Final Exam

Catalog Description:
Algebraic, rational, and radical expressions; functions and graphs; quadratic equations; absolute value; inequalities; and applications.

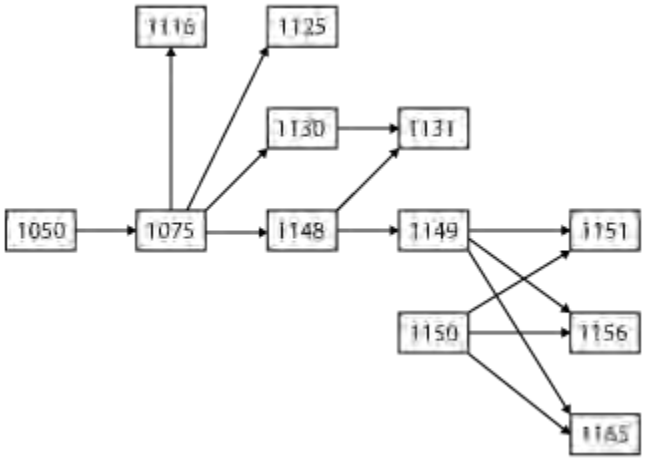
Prerequisite:
Math Placement Level S, a grade of C– or better in Math 1050, or credit for Math 75 or 1074.

Exclusions:
Not open to students with credit for any higher numbered math class, or for any quarter math class numbered higher than 75.

Text:
Beginning and Intermediate Algebra (4th ed), OSU Custom version, Miller, O'Neill & Hyde, McGraw-Hill, ISBN 9781259541650

Follow-up Courses:
- Math 1116 for students in liberal arts or students in the precertification programs on regional campuses.
- Math 1125 for students intending to pursue a M.Ed. in early or middle childhood.
- Math 1130 College Algebra for Business
- Math 1148 Traditional College Algebra

Sequencing Chart:



Topics List:

Ch. 4 Linear Inequalities
- 4.1 Solving linear inequalities using addition & subtraction
- 4.2 Solving linear inequalities using multiplication & division
- 4.3 Solving compound inequalities
- 4.4 Solving absolute value equations & inequalities
- 4.5 Graphing systems of inequalities in two variables

Ch. 6 Factoring Polynomials
- 6.1 Introduction to factoring polynomials
- 6.2 Factoring trinomials of the form x^2+bx+c
- 6.3 Factoring trinomials of the form ax^2+bx+c
- 6.4 Factoring special binomials
- 6.5 Factoring by grouping; General strategies for factoring
- 6.6 Solving equations by factoring

Ch. 9 Rational Functions
- 9.1 Graphs of rational functions
- 9.2 Reducing rational expressions; Multiplying and dividing rational expressions
- 9.3 Adding and subtracting rational expressions
- 9.4 Combining operations; Complex rational expressions
- 9.5 Solving equations containing rational expressions
- 9.6 Inverse and joint variation; Other applications yielding equations with fractions

Ch. 7 Solving Quadratic Equations
- 7.1 Extraction of roots and properties of square roots
- 7.2 Solving quadratic equations by completing the square
- 7.3 The quadratic formula
- 7.4 Applications of quadratic equations
- 7.5 Complex numbers; Solving quadratic equations with complex solutions

Ch. 8 Functions: Linear, Absolute Value, and Quadratic
- 8.1 Functions and representations of functions
- 8.2 Linear Functions
- 8.3 Absolute value functions
- 8.4 Quadratic functions

Ch. 10 Square Root & Cube Root Functions and Rational Exponents
- 10.1 Evaluating radical expressions
- 10.2 Adding & subtracting radical expressions
- 10.3 Multiplying & dividing radical expressions
- 10.4 Solving equations containing radical expressions
- 10.5 Rational exponents & radicals

Catalog Description:
Critical thinking and problem solving, with relevant topics met in everyday life. Appropriate for non-science majors.

Prerequisite:
Math Placement Level R or higher; or credit for 1075, 75, 104, 1073 or 1074;
or ACT math score ≥ 22 or SAT math score ≥ 520 (scores must be less than 2 years old).

Exclusions:
Not open to students with credit for Math 1152 or higher, or for quarter math class numbered 153 or higher.

Purpose of Course:
The emphasis in this course is on intuitive understanding and developing some facility for applying mathematical ideas to problem solving.

Follow-up Courses:
None. Math 1116 is a terminal course.

Text:
Excursions in Modern Mathematics, 8th edition, by Tannenbaum, Pearson,
ISBN 9780321825735

Topics List:

1. Units - Converting between units and unit systems and understanding how and why those conversions work
2. Percentages - Computing with percentages, percentage increases and decreases, and correcting misconceptions relating to percentages
3. Income Taxes - Using Federal Income taxes and how they are calculated to investigate and understand tiered systems based on percentages
4. Linear Functions & Models - Understanding and creating linear functions & models and how they relate to real world contexts
5. Exponential Functions & Models - Understanding and creating exponential functions & models and how they relate to real world contexts
6. Understanding measures of data - Looking more deeply at mean, median, and mode, as well as gaining a conceptual understanding of standard deviation and percentiles and what they tell us in real world contexts
7. Credit Cards & Mortgages - Using credit cards and mortgages to understand real world loans and gain a general understand of how they work and how to think critically about loan options

Catalog Description:
Topics in geometry for architecture majors.

Prerequisite:
Enrollment in the School of Architecture and: Math Placement Level L or M; C- or better in 1148 or 1150; or credit for 148 or 150.

Purpose of Course:
The majority of the audience is made up of Architecture majors for whom the course is a requirement. The intent of the course is to introduce these students to the mathematics inherent in 2D and 3D design. Moreover, there is an emphasis on similar figures and the issues that arise when scaling lengths, areas, and volumes.

Follow-up Courses:
There are really no follow-up courses. To start any other mathematics sequence will probably involve beginning at an appropriate entry level course. Students interested in further course work in mathematics should consult the Mathematics Advisors in 250 Mathematics Bldg.

Text:
Course Notes, by Snapp

Topics List:

1. Geometric models, transformations, matrices.
2. Plane tessellations, concepts of symmetry.
3. Polyhedra: Platonic and Archimedean.
4. Invariants: area, volume, Euler characteristic.
5. Mathematics of perspective drawing.
6. String art: curves defined as envelopes of tangent lines, ruled surfaces.
7. Discrete curvature: Descartes theorem and beyond.
8. Higher dimensions: tesseracts and other 4-D polyhedra.

Catalog Description:
This is the first course of a two course sequence covering precalculus. In this first course, topics covered will include an introduction to functions (linear, polynomial and rational), equations and inequalities along with appropriate review. This course is designed with an emphasis on reviewing these fundamental basic algebra skills as they apply to precalculus in a just-in-time manner.

Prerequisite:
A grade of C- or above in 1075; or grade of B- or above in 1050; or Math Placement level R. Not open to students with credit for 1121 or above.

Exclusions:
Not open to students with credit for 1121 or above.

Follow-up Courses:
Math 1121

Text:
Precalculus with Review 1 in Ximera.

Topics List:

1 Variables and CoVariation
- 1.1 Quantitative Reasoning: Units, Estimates, Percents
- 1.2 Relations and Graphs: Cartesian Coordinates, Relations, Famous Functions
- 1.3 Changing in Tandem

Midterm 1

2 Comparing Lines and Exponentials
- 2.1 Linear Equations: Patterns, Slope, Equations of Lines
- 2.2 Linear Modeling
- 2.3 Exponential Modeling: Exponent Rules, Early Exponentials

Midterm 2

3 Functions
- 3.1 What is a Function?
- 3.2 Function Properties, Inverse Functions, Famous Function Properties

- 3.3 Average Rate of Change of Functions
- 3.4 Exponential Functions Revisited
  - 3.4.1 Exponential Functions
  - 3.4.2 Modeling with Exponential Functions Revisited
  - 3.4.3 The Special Number e

Midterm 3

- 4 Building New Functions from Famous Functions
  - 4.1 Building New Functions
    - 4.1.1 Algebra of Functions
    - 4.1.2 Creating a New Function: Tangent
  - 4.2 Polynomials
    - 4.2.1 Parabolas
    - 4.2.2 Definition of Polynomials
  - 4.3 Rational Functions
    - 4.3.1 The Famous Function f(x) = 1/x
    - 4.3.2 Polynomial Long Division
    - 4.3.3 The Definition of a Rational Function

Midterm 4

- 5 Domain and Range
  - 5.1 Domain
  - 5.2 Range, Famous Functions Updated
  - 5.3 Composition of Functions, Domains and Ranges

Midterm 5

- 6 Zeros
  - 6.1 What are the Zeros of Functions?
  - 6.2 Zeros of Polynomials
  - 6.3 Zeros of Famous Functions
    - 6.3.1 Zeros of Rational Functions
    - 6.3.2 Zeros of Functions with Radicals
    - 6.3.3 Zeros of Exponential Functions

Midterm 6

- 7 Manipulating Functions
  - 7.1 Function Transformations
    - 7.1.1 Vertical and Horizontal Shifts
    - 7.1.2 Stretching Functions
    - 7.1.3 Reflections of Functions

Final

Catalog Description:
This is the second course of a two-course sequence covering precalculus. In this course, topics covered will include systems of equations, trigonometry, inverse functions, and applications of functions (including previews of some calculus topics) along with appropriate review. This course is designed with an added emphasis on conceptual understanding of these topics as a preparation for Calculus.

Prerequisite:
A grade of C- or above in 1120 or 1148

Exclusions:
Not open to students with credit for 1121 or above.

Follow-up Courses:
Math 1151

Text:
Precalculus with Review 2 in Ximera.

Topics List:

8 Working with More Variables
- 8.1 Linear Systems of Equations
- 8.2 Non-linear Systems
- 8.3 Applications of Systems

Midterm 1

9 Origins of Trig

- 9.1 Right Triangle Trigonometry
- 9.2 The Unit Circle
- 9.3 Trig Identities
  - 9.3.1 Pythagorean Identities
  - 9.3.2 Half and Double Angle Formulas
  - 9.3.3 Simplifying Trig Expressions and Equations with Identities

Midterm 2

10 Trigonometric Functions

- 10.1 From the Unit Circle to The Function Graph
- 10.2 Trig Functions as Functions, Transformations
- 10.3 Applications of Trig Functions

Midterm 3

11 Some Applications of Functions

- 11.1 Displacement vs. Distance Traveled
- 11.2 Solving Inequalities Graphically or Without a Graph
- 11.3 Average Rate of Change: Difference Quotients

Midterm 4

12 Inverse Functions in Depth

- 12.1 Inverse Functions Revisted
- 12.2 Properties of Logarithms, Solving Logarithmic Equations, Applications
- 12.3 Inverse Trigonometry and applications

Midterm 5

13 Preparation for Calculus

- 13.1 What is Calculus?
- 13.2 Ideas of Calculus 1
  - 13.2.1 Approximating with Nearby Values
  - 13.2.2 Secant Lines with Nearby Points
  - 13.2.3 Algebra of Secant Lines
  - 13.2.4 Applications of Secant Lines
- 13.3 Summation Notation and Approximating Areas

Midterm 6

14 Functions – The Big Picture

Final

Catalog Description:
Math 1125 involves numbers, operations, geometry, measurement, and mathematical reasoning for prospective elementary school teachers.

Prerequisite:
A grade of C- or above in 1075; or credit for 1074, 75, or 104; or Math Placement Level R or above; or ACT math score ≥ 22 or SAT math score ≥ 520 (scores must be less than 2 years old) and enrollment in Early Childhood or Special Education major, or in Middle Childhood major or pre-major with area of concentration different than Math.

Exclusions:
Not open to students with credit for 106.

Purpose of Course:
To develop an appreciation of, and basic competency in, the use of analytical thought in the development of a cohesive body of useful mathematical knowledge, with special emphasis on topics encountered in elementary and middle school mathematics programs. Math 1125 addresses the meaning of whole numbers, integers, rational numbers, and operations with these, number theory, and algebraic thinking. *Appropriate only for those preparing to become early childhood educators and for those preparing to teach subjects other than math in middle school.*

Follow-up Courses:
Math 1126.

Text:
Mathematics for Elementary Teachers, with Activity Manual, 4rd Edition, by Sybilla Beckmann, Pearson, ISBN for the package is 9780321836715 (loose-leaf) and Student Packet.

Topics List:
1. Counting and the decimal system.
2. Fractions and integers and their meaning.
3. Addition and subtraction of fractions, decimals, and integers.
4. Multiplication of fractions, decimals, and integers.
5. Division of fractions, decimals, and integers.
6. Ratios and proportional reasoning.
7. Number theory: factors and multiples, LCM, GCF, divisibility tests, prime numbers, unique factorization, notations for fractions and decimals.
8. Algebraic thinking: writing expressions, solving equations, sequences.
9. Problem solving and justification are themes of the course.

*Currently taught in either lecture/recitation or workshop format.

Catalog Description:
Continuation of 1125: Math 1126 involves geometry, measurement, number theory, algebraic thinking, counting techniques, probability, a mathematical reasoning for prospective elementary school teachers.

Prerequisite:
A grade of C- or above in 1125; and enrollment in Early Childhood or Special Education major, or in Middle Childhood major or pre-major with area of concentration different than Math.

Exclusions:
Not open to students with credit for 107.

Purpose of Course:
To develop an appreciation of, and basic competency in, the use of analytical thought in the development of a cohesive body of useful mathematical knowledge, with special emphasis on topics encountered in elementary and middle school mathematics programs. Math 1126 addresses basic geometric concepts and measurement, symmetry and rigid motions, congruence, similarity and scaling, coordinate geometry, algebraic thinking, linear functions, counting techniques and probability. *Appropriate for those preparing to become early childhood educators and for those preparing to teach subjects other than math in middle school.*

Text:
Mathematics for Elementary Teachers, with Activity Manual, 4rd Edition, by Sybilla Beckmann, Pearson, ISBN for the package is 9780321836715 (loose-leaf) and Student Packet.

Topics List:

1. Spatial visualization and basic geometric concepts: angles, 2- and 3-D shapes and their properties.
2. Measurement: meaning of length, area, volume, measurement techniques, unit conversion, actions preserving area/volume, and scaling.
3. Transformations: symmetry, congruence, similarity.
4. Geometric constructions with various tools (compass, paper folding).
5. Algebraic thinking: expressions, measurement formulas, scaling, functions, use of formulas, graphs, and tables, sequences, and coordinate geometry.
6. Counting: inclusion/exclusion, fundamental counting principle, tree diagrams, permutations and combinations, Pascal's triangle.
7. Basic ideas of probability: Law of Large Numbers, sample and event spaces, use of tree diagrams, simulations, and discussion of common misconceptions.
8. Problem solving and justifications at multiple levels are themes of the course.

*Currently taught in either lecture/recitation or workshop format.

Catalog Description:
Algebraic, exponential, and logarithmic functions. Matrix algebra. Applications to business.

Prerequisite:
Math Placement Level N; C- or better in 1075; or credit for 104; or ACT math score ≥ 22 or SAT math score ≥ 520 (scores must be less than 2 years old).

Exclusions:
Not open to students with credit for 1131 or for any math course numbered 1149 or higher, or a quarter-system math course numbered 150 or higher.

Purpose of Course:
Math 1130 is a pre-calculus course with a finance section slanted toward a business program. The applications are business related.

Follow-up Course:
Math 1131

Text:
Introductory Mathematical Analysis for Business, Economics, and the Life and Social Sciences, 13th Edition; by Haeussler, Paul, and Wood; published by Pearson; ISBN 9780321732378

Topics List:

Ch. 1 Review of Algebra
- 0.7 Equations, In Particular Linear Equations.
- 0.8 Quadratic Equations.
- 1.2 Linear Inequalities.
- 1.3 Applications of Inequalities.
- 1.6 Sequences

Ch. 2 Functions
- 2.1 Functions.
- 2.2 Special functions.
- 2.3 Combinations of functions.
- 2.4 Inverse Functions.
- 2.5 Graphs of functions

Ch. 3 Linear and Quadratic Functions

- 3.1 Lines
- 3.2 Applications and Linear Functions.
- 3.3 Quadratic Functions
- 3.4 Systems of Linear Equations.
- 3.6 Applications of Systems of Equations.

Ch. 4 Exponential and Logarithmic Functions

- 4.1 Exponential Functions.
- 4.2 Logarithmic functions.
- 4.3 Properties of Logarithms.
- 4.4 Logarithmic and Exponential Equations.

Ch. 5 Mathematics of Finance

- 5.1 Compound Interest.
- 5.2 Present Value.
- 5.3 Interest Compounded Continuously.
- 5.4 Annuities
- 5.5 Amortization of Loans.

Ch. 6 Matrix Algebra

- 6.1 Matrices.
- 6.2 Matrix Addition and Scalar Multiplication.
- 6.3 Matrix Multiplication.
- 6.4 Solving Systems by Reducing Matrices.
- 6.6 Inverses

Catalog Description:
Survey of calculus of one and several variables; applications to business.

Prerequisite:
Math Placement Level L; C- or better in 1130, 1148, 1144, or 1150; credit for 130 or 148.

Exclusions:
Not open to students with credit for a math course numbered 1151 (151.xx) or higher, or for 132 or 1134.

Text:
Columbus Campus: Business Calculus developed by Ximera
Regional Campuses: *Introductory Mathematical Analysis for Business, Economics, and the Life and Social Sciences*, 13th Edition, by Haeussler, Paul, Wood, published by Pearson: ISBN-10: 1-256-96609-6, ISBN-13: 978-1-256-96609-8.

Topics List:

1. Limits
2. Continuity
3. Continuity and Intervals
4. The Derivative
5. Rules of Differentiation
6. Rates of Change
7. Product and Quotient Rules
8. Chain Rule
9. Derivatives of Exponential Functions
10. Derivatives of Logarithmic Functions

Midterm 1

11. Implicit Differentiation
12. Logarithmic Differentiation
13. Higher-Order Derivatives
14. Differentials
15. Local Extrema
16. Concavity
17. Second-Derivative Test
18. Absolute Extrema
19. Asymptotes
20. Graphing
21. Applied Maxima and Minima
22. The Indefinite Integral

Midterm 2

23. Integration with Initial Conditions
24. Approximating Areas Under Curves
25. The Definite Integral
26. The Fundamental Theorem of Calculus
27. Integration by Substitution
28. Working with Substitution
29. Area Between Curves
30. Consumers' and Producer's Surplus
31. Differential Equations
32. Partial Derivatives

Midterm 3

33. Applications of Partial Derivatives
34. Higher-Order Partial Derivatives

Catalog Description:
This course is the first in a two semester sequence for teachers of elementary and middle grade students. This course focuses on concepts of numbers and arithmetic operations, including modern and historical perspectives.

Prerequisite:
A grade of C- or above in 1075; or credit for 1074, 75, or 104; or Math Placement Level R or above; or ACT math subscore of 22 or higher that is less than 2 years old.

Exclusions:
Not open to students with credit for 106.

Text:
Mathematics for Elementary Teachers, with Activity Manual, 4th Edition, by Sybilla Beckmann, Pearson, ISBN for the package is 9780321836715 (loose-leaf).

Purpose:
This course covers the concepts of whole numbers (positive and negative), place value (base-ten and alternate bases), decimals, and fractions. Some content on irrational numbers appears at the end, and this is extended in Algebra and coordinate geometry for teachers (2137). The four arithmetic operations are covered both conceptually and algorithmically. Attention is given to ensuring that students can perform the algorithms correctly and explain why they give accurate answers. Lastly, the course covers the concepts of proportions and how they are related both to multiplication/division and to fractions. Factors, divisibility, and some elementary number theory complete the course.

Topics List:
1. Counting numbers, decimals
2. Meaning of fractions
3. Meaning of addition and subtraction
4. Meaning of multiplication
5. Multiplying fractions, decimals, integers
6. Meaning of division
7. Dividing fractions, decimals, integers
8. Meaning of ratios, rates, proportions
9. Greatest common divisor, least common multiple
10. Rational and irrational numbers

Catalog Description:
This course is the second in a two semester sequence for teachers of elementary and middle grade students. This course focuses on concepts of measurement and geometry, including modern and historical perspectives.

Prerequisite:
A grade of C- or above in *"Number and Operations for Teachers"* (Math 1135)

Text:
Mathematics for Elementary Teachers, with Activity Manual, 4th Edition, by Sybilla Beckmann, Pearson, ISBN for the package is 9780321836715 (loose-leaf).

Recommended Supplemental Texts:
- *Geometric Structures: An Inquiry-Based Approach for Prospective Elementary and Middle School Teachers*, by Douglas Aichele and John Wolfe, Pearson, ISBN 9780131483927
- *Elementary Geometry for Teachers*, by Thomas Parker and Scott Baldridge, Sefton-Ash Publishing, ISBN 9780974814056

Purpose:
The course consists of fundamental topics in Euclidean geometry starting with measurement. This includes the concepts of length, area, volume, angles, units of measurement, precision and error.

The basic properties of two and three dimensional geometric shapes and their relationships are a central part of the course. Special emphasis is put on geometric reasoning through problem solving, including unknown angle, length, area, and volume. The course also covers topics on transformations in the plane, symmetries, congruence, and similarity. Some geometric constructions and basic geometric proofs are included.

Additional topics include an introduction to functions and equations, primarily in the linear case, and a brief introduction to probability.

Topics List:
1. Measurement
2. Planar shapes
3. Polyhedra
4. Plane geometry
5. Transformations in the plane, congruence, symmetry
6. Linear equations and graphs
7. Algebra and linear equations
8. Probability

Catalog Description:
This is the first of a two semester course sequence. The topics covered in Math 1140 will include differential calculus of one real variable, with review of important algebra and pre-calculus concepts. Calculus with Review I is a course designed with an emphasis on reviewing these fundamental pre-calculus skills as they apply to calculus.

Prerequisite:
A grade of C- or above in 1148 and 1149, or in 1144, 1150, or 150, or Math Placement Level L.

Exclusions:
Not open to students with credit for 1141, or 1151 or above, or 151.xx or above.

Text:
calculus with review developed by XIMERA

Topics List:

I.1 Equations and Inequalities
I.2 Understanding functions
I.3 What is a limit?
I.4 Polynomial functions
I.5 Rational functions
I.6 Limit laws
I.7 (In)determinate forms
I.8 Using limits to detect asymptotes
I.9 Continuity and the Intermediate Value Theorem

Midterm 1

II.10 An application of limits
II.11 Definition of derivative
II.12 Derivatives as functions
II.13 Rules of differentiation
II.14 Product rule and quotient rule
II.15 Chain Rule

Midterm 2

III.16 Exponential and Logarithmic functions
III.17 Derivatives of exponential functions
III.18 Higher order derivatives and graphs
III.19 Trigonometric functions
III.20 Derivatives of trigonometric functions
III.21 Maximums and minimums

Midterm 3

IV.22 Mean Value Theorem
IV.23 Optimization
IV.24 Applied optimization

Final

Catalog Description:
This is the second of a two semester course sequence. The topics covered in Math 1141 will include differential calculus of one real variable, with review of important algebra and pre-calculus concepts. Math 1141 is a course designed with an emphasis on reviewing these fundamental pre-calculus skills as they apply to calculus.

Prerequisite:
A grade of C- or above in 1140.

Exclusions:
Not open to students with credit for 1151 or above, or 151.xx or above.

Text:
calculus with review developed by XIMERA

Topics List:

V.25 Review of Limits
V.26 Review of differentiation
V.27 Linear approximation
V.28 Concepts of graphing functions
V.29 Implicit differentiation
V.30 Logarithmic differentiation

Midterm 1

VI.31 Inverse Trigonometric Functions
VI.32 Derivatives of inverse trigonometric functions
VI.33 More than one rate
VI.34 Applied related rates
VI.35 L'Hopital's rule
VI.36 Antiderivatives
VI.37 Differential Equations

Midterm 2

VII.38 Approximating the area under a curve
VII.39 Definite integrals
VII.40 Antiderivatives and area
VII.41 First Fundamental Theorem of Calculus
VII.42 Second Fundamental Theorem of Calculus
VII.43 Applications of integrals

Midterm 3

VIII.44 The idea of substitution
VIII.45 Working with substitution

Final

THE OHIO STATE UNIVERSITY

Mathematics 1148
College Algebra
Autumn, Spring, Summer
4 credits

Catalog Description:
Functions: polynomial, rational, radical, exponential, and logarithmic. Introduction to right-angle trigonometry. Applications.

Prerequisite:
Math Placement Level N; C- or better in 1075; or credit for 104 or 148; or ACT math score ≥ 22 or SAT math score ≥ 520 (scores must be less than 2 years old).

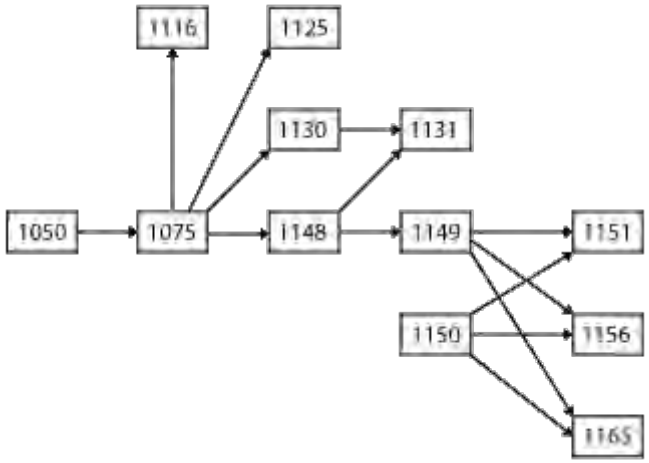
Exclusions:
Not open to students with credit for 1144 or 1150 or higher, or for a quarter-system math course numbered 150 or higher.

Purpose:
College Algebra provides students a college level academic experience that emphasizes the use of algebra and functions in problem solving and modeling, where solutions to problems in real-world situations are formulated, validated, and analyzed using mental, paper-and-pencil, algebraic and technology-based techniques as appropriate using a variety of mathematical notation. Students should develop a framework of problem-solving techniques (e.g., read the problem at least twice; define variables; sketch and label a diagram; list what is given; restate the question asked; identify variables and parameters; use analytical, numerical and graphical solution methods as appropriate; determine the plausibility of and interpret solutions). – Adapted from the MAA/CUPM CRAFTY 2007 College Algebra Guidelines. This course is intended to satisfy the requirements of the Ohio Board of Regents TMM001 College Algebra course with learning outcomes specified in: http://regents.ohio.gov/transfer/otm/otm-learning-outcomes.php

Text:
College Algebra & Trigonometry, 1st Edition, by Miller and Gerken, published by McGraw-Hill.
ISBN: 9781259976612

Technology: All students are required to have a graphing calculator, TI-83 or TI-84.
Note: Any calculators (including TI-89 and TI-92) that use a Computer Algebra System (CAS) are not permitted.

Sequencing Chart:



Topics List:

Week 1	Section 1.7 – Inequalities
	Section 2.3 – Functions and Relations
Week 2	Section 2.4 – Linear Equations in Two Variables
	Section 2.5 – Applications of Linear Equations
Week 3	Section 9.1 – Systems of Linear Equations in Two Variables
	Section 9.2 – Systems of Linear Equations in Three Variables
Week 4	Section 2.6 – Transformations of Graphs
	Section 2.7 – Analyzing Graphs of Functions
Week 5	Test 1
	Section 2.8 – Algebra of Functions and Composition
Week 6	Section 3.1 – Quadratic Functions and Applications
	Section 3.2 – Polynomial Functions
Week 7	Section 3.3 – Division of Polynomials
	Section 3.5 – Rational Functions
Week 8	Section 3.5 – Rational Functions
	Section 3.6 – Polynomial and Rational Inequalities
Week 9	Test 2
Week 10	Section 4.1 – Inverse Functions
	Section 4.2 – Exponential Functions
Week 11	Section 4.2 – Exponential Functions
	Section 4.3 – Logarithmic Functions
Week 12	Section 4.3 – Logarithmic Functions
	Section 4.4 – Properties of Logarithms
Week 13	Section 4.4 – Properties of Logarithms
Week 14	Section 4.5 – Exponential and Logarithmic Equations
	Section 4.6 – Modeling with Exponential and Logarithmic Functions
	Comprehensive review, Final Exam

Catalog Description:
Trigonometric functions and their properties. Vectors, polar coordinates and complex numbers.

Prerequisite:
C- or better in 1148, or permission of department.

Exclusions:
Not open to students with credit for 1144, or for any math course numbered 1150 or higher.

Text:
College Algebra & Trigonometry Mathematics 1e, by **Miller and Gerken**, ISBN 9781259976612. This textbook is packaged with an access code to Connect Math for a period of 720 days. It may be purchased at the bookstore or online via Carmen/Canvas.

Technology:
A graphing calculator is a required component in this course. It is recommended that you use a TI-83, TI-83 plus, or a TI-84. Note that the TI-89, TI-92, and calculators that use a Computer Algebra System are not permitted.

Topics List:

5.1 Angles and Their Measure
5.2 Right Triangle Trigonometry
5.3 Trigonometric Functions of any Angle
5.4 Trigonometric Functions and the Unit Circle
5.5 Graphs of Sine and Cosine Functions. **Omit sinusoidal behavior.**
5.6 Graphs of Other Trigonometric Functions.

Midterm 1

5.7 Inverse Trigonometric Functions. **Omit inverse cot(t), sec(t), and csc(t).**
6.1 Fundamental Trigonometric Identities
6.2 Sum and Difference Formulas
6.3 Double-Angle and Half-Angle Formulas
6.5 Trigonometric Functions. **Solving graphically is optional.**
7.2 The Law of Sines
7.3 The Law of Cosines

Midterm 2

8.3 Complex Numbers in Polar Form. **Omit n^{th} roots of complex numbers.**
8.4 Vectors
8.5 Dot Product
11.1 The Ellipse. **Centered at the origin only (omit center (p,q)).**
11.2 The Hyperbola. **Centered at the origin only (omit center (p,q)).**
11.3 The Parabola. **With vertex at the origin (omit vertex (p,q)).**

THE OHIO STATE UNIVERSITY

Mathematics 1150
Precalculus
Autumn, Spring
5 credits

Catalog Description:
Functions: polynomial, rational, radical, exponential, logarithmic, trigonometric, and inverse trigonometric. Applications.

Prerequisite:
Math Placement Level M.

Exclusions:
Not open to students with credit for 1144, 1148, 1149, for any higher numbered math course, or for any quarter-system math course 150 or higher.

Text:
College Algebra & Trigonometry Mathematics 1e, by **Miller and Gerken**, ISBN 9781259976612. This textbook is packaged with an access code to Connect Math for a period of 720 days. It may be purchased at the bookstore or online via Carmen/Canvas.

Technology:
Every student is required to have a graphing calculator comparable in capability to a TI-83 or TI-84. However, calculators with symbolic algebra capabilities are not allowed during exams or quizzes.

Topics List:

2.3 Functions and Relations.
2.4 Linear Functions. **Cover the average rate of change only.**
2.6 Transformations of Graphs.
2.7 Analyzing Graphs of Functions. **Omit step functions**.
2.8 Algebra and Composition of Functions.
3.1 Quadratic Functions. **Omit models using regression.**
3.2 Introduction to Polynomial Functions.
3.3 Division of Polynomials and The Remainder and Factor Theorems. **Omit Synthetic Division.**
3.4 Zeros of Polynomials. **Cover only paragraph 2 ("Apply the fundamental theorem of algebra").**
3.5 Rational Functions.
3.6 Polynomial and Rational Inequalities. **Omit applications.**
4.1 Inverse functions.

Midterm 1

4.2 Exponential Functions.
4.3 Logarithmic Functions. **Cover example 10 (magnitude of earthquake)**
4.4 Properties of Logarithms.
4.5 Exponential and Logarithmic Equations.
4.6 Modeling with Exponential and Logarithmic Functions. **Omit logistic growth and models using regression**.
5.1 Angles and Their Measure.
5.2 Right Triangle Trigonometry.
5.3 Trigonometric Functions of any Angle.
5.4 Trigonometric Functions and The Unit Circle.
5.5 Graphs of Sine and Cosine Functions. **Omit sinusoidal behavior**.
5.6 Graphs of Other Trigonometric Functions.
5.7 Inverse Trigonometric Functions. **Omit inverse cot(t), sec(t), and csc(t)**.
6.1 Fundamental Trigonometric Identities.

Midterm 2

6.2 Sum and Difference Formulas.
6.3 Double-Angle and Half-Angle Formulas.
6.5 Trigonometric Equations. **Solving graphically is optional**.
7.2 The Law of Sines.
7.3 The Law of Cosines.
8.3 Complex Numbers in Polar Form. **Omit n^{th} roots of complex numbers**.
8.4 Vectors.
8.5 Dot Product.
9.1 Systems of Linear Equations in Two Variables. **Cover briefly**.
9.2 Systems of Linear Equations in Three Variables. **Omit modeling.**
11.1 The Ellipse. **Centered at the origin only (omit center (p,q)).**
11.2 The Hyperbola. **Centered at the origin only (omit center (p,q)).**

Midterm 3

11.3 The Parabola. **With vertex at the origin (omit vertex (p,q)).**

THE OHIO STATE UNIVERSITY

Mathematics 1151
Calculus I
Autumn, Spring, Summer
5 credits

Catalog Description:
Differential and integral calculus of one real variable.

Prerequisite:
Math Placement Level L, or C- or better in: 1150, or in both 1148 & 1149; or in 150 or 1144.

Exclusions:
Not open to students with credit for any higher numbered math class.

Text:
Calculus I developed by Ximera

Topics List:

- Understanding Functions
- Review of famous functions
- What is a limit?
- Limit laws
- (In)determinate forms
- Using limits to detect asymptotes
- Continuity & Intermediate Value Theorem
- An application of limits

Midterm 1

- Definition of the derivative
- Derivatives as functions
- Rules of differentiation
- Product rule and the quotient rule
- Chain rule
- Higher order derivatives and graphs
- Implicit differentiation
- Logarithmic differentiation
- Derivatives of inverse functions
- More than one rate
- Applied related rates
- Maximums and minimums
- Concepts of graphing functions
- Computations for graphing functions
- Mean value theorem

Midterm 2

- Linear approximation
- Optimization Section
- Applied optimization
- L'Hopital's rule
- Antiderivatives
- Approximating the area under a curve
- Definite integrals

Midterm 3

- Antiderivatives and area
- First Fundamental Theorem of Calculus
- Second Fundamental Theorem of Calculus
- Applications of integrals
- The idea of substitution
- Working with substitution

Final

Catalog Description:
Integral calculus, sequences and series, parametric curves, polar coordinates, vectors.

Prerequisite:
C- or better in 1141, 1151, 1156, 152.xx, 161.xx or 161.01H; or 114 or 1114.

Exclusions:
Not open to students with credit for any higher numbered math class or with credit for quarter-system Math courses numbered 153.xx or above.

Text:
Calculus II developed by Ximera

Topic List:

- § A Review of Integration
- § Area Between Curves
- § Accumulated Cross Sections
- § Solids of Revolution
- § Length of Curves
- § Physical Applications
- § Integration by Parts
- § Trigonometric Integrals
- § Trigonometric Substitution

Midterm 1

- § Partial Fraction Decomposition
- § Improper Integrals
- § Sequences
- § Limits of Sequences
- § Sums of Sequences
- § Divergence Test
- § Integral Tests & Alternating Series
- § Remainders
- § Ratio Test & Root Test
- § Comparison Test & Limit Comp. Test
- § Absolute & Conditional Convergence

Midterm 2

- § Approximating Functions with Polynomials
- § Power Series
- § Introduction to Taylor Series
- § Calculus and Taylor Series
- § Introduction to Differential Equations
- § Numerical Methods & Direction Fields
- § Separable Differential Equations
- § Modeling With Differential Equations

Midterm 3

- § Parametric Equations
- § Introduction to Polar Coordinates
- § Calculus in Polar Coordinates

Final

THE OHIO STATE UNIVERSITY

Mathematics 1154
Calculus I for Engineering Technology
Autumn, Spring
4 credits

Catalog Description:
Calculus topics including limits, differentiation, integration, optimization, and approximation with an emphasis on building mathematical intuition, problem solving ability and using appropriate technology to find solutions.

Prerequisite: A grade of C- or above in 1148 and 1149, or in 1144, 1150, or 150, or Math Placement L

Exclusions:
Not open to students with credit for any course 2153 or above, or for any quarter-system class 254.xx or above.

Follow-up Course:
Math 1155

Text:
None. Class notes will cover all the important ideas and formulas.

Topics List:

I. Exam 1
1. Lines, regression
2. Derivatives and integrals in physics
3. Vectors and parametrization
4. Limits, definition of derivative
5. Derivatives and graphs
6. Definition of definite integral

II. Exam 2
7. Calculus of polynomials
8. Fundamental Theorem of Calculus
9. Initial value problems
10. Area between curves
11. Derivative rules
12. Calculus of trigonometric functions
13. Circular motion, harmonic motion
14. Calculus of exponentials and logarithms
15. Damped oscillation

III. Exam 3
15. Substitution
16. Volumes of revolution
17. Integrals for physical quantities
18. Maxima and minima, optimization
19. Linear programming
20. Least squares regression
21. Related rates

Catalog Description:
Calculus topics including related rates, Taylor Polynomial approximations, differential equations and functions of several variables with an emphasis on building mathematical intuition, problem solving and using appropriate technology to find solutions.

Course Learning Outcomes: Students develop skills in quantitative literacy and logical reasoning, including the ability to identify valid arguments, and use mathematical models.

- Create, manipulate and interpret multiple representations of data among variables.
- Work in groups to solve complicated problems and enhance communication skills through independent work on related portions of a project and synthesize results
- Set up models and use technology where appropriate to simulate a system through viewing an unfamiliar situation, identifying key concepts, formulas; making predictions

Prerequisite: C- or above in Math 1154

Text:

None. Class notes will cover all the important ideas and formulas.

Topics List:

I. Exam 1
1. Linear approximation
2. Differentials
3. Taylor polynomials

II. Exam 2
1. Systems of ordinary differential equations
2. Approximate solutions to ODEs
3. Physical applications of ODEs
4. Engineering applications of ODEs
5. Fourier Series
6. Partial differential equations

III. Exam 3
1. Functions of several variables
2. Vectors
3. Slopes on surfaces
4. Tangent planes
5. Optimization in several variables
6. Optimization with constraints
7. Vector fields and line integrals

IV. Final Exam additional topics
1. Double and triple integrals for physical quantities
2. Divergence and curl
3. Green's Theorem
4. Divergence Theorem

Catalog Description:
Limits, continuity, derivatives, mean value theorem, extrema, curve sketching, related rates, differentiation of the trig, log, and exponential functions, basic integration techniques, with particular motivations from and application to the Biological Sciences.

Prerequisite:
A grade of C- or above in 1148 and 1149, or a grade of C- or above in 1150, or credit for 150, or Math Placement Level L. Not open to students with credit for 1151 (151.xx) or above. GE quant reason math and logical analysis course.

Exclusions:
Not open to students with credit for 1151, or with credit for any higher numbered math class.

Purpose of Course:
To provide students with a solid foundation in one-variable differential calculus, to model and analyze phenomena in the Biological Sciences.

Follow-up Course:
Math 1157

Text:
Calculus for Biology and Medicine, 3rd Edition, by Claudia Neuhauser, Pearson, ISBN 9780321644688

Topics List:

1.2	Elementary Functions
1.3/2.1	Graphing/Exponential Growth and Decay
2.2	Sequences
3.1-3.4	Limits and Continuity
3.5	Properties of Continuous Functions
4.1	Derivatives
4.2-4.3	Rules of Differentiation, Product and Quotient Rules
4.4	Chain Rule and Higher Derivatives
4.5-4.7	Derivatives of Special Functions and Inverse Functions
5.1-5.3	Extrema, Mean Value Theorem, Monotonicity, Concavity, Inflection Points
5.4	Optimization
5.5	L'Hospital's Rule
5.8	Antiderivatives
6.1	The Definite Integral
6.2	The Fundamental Theorem of Calculus
6.3	Applications of Integration
7.1-7.2	Integration Techniques
	Also: Small-group Projects

Catalog Description:
Models in life sciences using multivariable calculus, linear algebra, dynamical systems, and ordinary differential equations.

Prerequisite:
C- or better in: 1156, 1151, 1161.xx or 1181H; or credit for 152.xx.

Exclusions:
Not open to students with credit for 1152 or with credit for any higher numbered math class.

Purpose of Course:
To provide students with a solid foundation in one-variable calculus, to introduce multi-variable tools in a biological setting, to model and analyze phenomena in the life sciences.

Text:
Calculus for Biology and Medicine, 3rd Edition, by Claudia Neuhauser, Pearson, ISBN 9780321644688

Topics List:

7.3	Rational Functions and Partial Fractions
7.5	Numerical Integration
7.6	Taylor Approximation
8.1	Solving Differential Equations
8.2	Equilibria and Their Stability
9.1-9.2	Linear Systems and Matrices
9.3	Linear Maps, Eigenvectors, an Eigenvalues
10.3	Multivariable functions & Partial Derivatives
10.4	Tangent Planes, Differentiability, and Linearization
11.1-11.2	Linear Systems: Theory and Applications
11.3-11.4	Nonlinear Autonomous Systems: Theory and Applications
Also:	Small-group Projects

Catalog Description:
Differential and integral calculus of one real variable. This course is discontinued for 2021- 2022.

Prerequisites:
Math Placement Level L and previous calculus experience.

Exclusions:
For 1161.01: Not open to students with credit for any math course numbered 1152 or higher, or for the quarter-system math courses 151.xx and 152.xx, or for any quarter-system course numbered 162.xx or higher.
For 1161.02: Intended for students in Freshman Engineering Honors.

Text:
Calculus for Scientists and Engineers: Early Transcendentals, 2nd OSU custom edition, by Briggs, Cochran, Gillett, Person, ISBN: 9781269753449

Topics:

2.1; 2.2	The Idea of Limits; Definition of Limits
2.2; 2.3	Definition of Limits; Limit Laws
2.4; 2.5	Infinite Limits; Limits at Infinity
2.5; 2.6	Limits at Infinity; Continuity, the Intermediate Value Theorem
2.7	Precise Definition of Limits
3.1	Introducing the Derivative
3.2; 3.3	Rules of Differentiation; Product and Quotient Rules
3.4; 3.5	Derivatives of Trig Functions; Derivatives as Rate of Change
3.5; 3.6	Derivatives as Rate of Change; The Chain Rule
3.7	Implicit Differentiation
	Midterm 1

3.8; 3.9	Derivatives of Logarithms and Exponential Functions; Derivatives of Inverse Functions
3.10	Related Rates
4.1	Maxima and Minima
4.2; 4.3	What derivatives Tell Us; Graphing
4.4	Optimization Problems
4.5; 4.6	Linear Approximations and Differentials; Mean Value Theorem
4.6; 4.7	Mean Value Theorem; L'Hopital's Rule
4.9	Antiderivatives
5.1	Approximating Areas under Curves, Sigma Notation
5.2	Definite Integrals
	Midterm 2
5.3	Fundamental Theorem of Calculus
5.4; 5.5	Working with Integrals; Substitution Rule
5.5; 6.1	Substitution Rule; Velocity and Net Change
6.2	Regions between Curves
6.3	Volumes by Slicing
6.4	Volumes by Shells
6.5; 6.6 11.5	Lengths of Curves; Surface Area
6.7	Physical Applications: Density & Mass, Work, Lifting Problems, Force & Pressure
6.8; 6.9	Log and Exponential Functions Again; Exponential Growth and Decay
7.1; 7.2	Integration: Basic Approaches; Integration by Parts
	Midterm 3
7.3	Trig Integrals
7.4	Trig Substitutions
7.5	Partial Fractions
7.8	Improper Integrals
	Final

Catalog Description:
Algebra and reasoning for middle school teachers.

Prerequisite:
A grade of C- or above in 1148 and 1149, or grade of C- or above in 1150, or credit for 150, or Math Placement Level L; and enrollment in Middle Childhood Education major within either College of Arts and Sciences or College of Education and Human Ecology with Math as an Area of Concentration.

Purpose of Course:
The purpose of the course is to prepare teachers of middle school students. In particular, it intends to deepen and extend the prospective teachers' content knowledge of the mathematics they will teach as well as their ability to reason with and communicate that knowledge.

Follow-up Courses:
Math 1166, Math 2167, and Math 2168

Text:
Course Notes, by B. Snapp
Recommended Text: Algebra Connections, by Papick, published by Pearson, ISBN 9780131449282

Topics List:
1. Number systems (whole, integer, rational, real): uses, notations (including place value), and comparison of size. Addition and Subtraction
2. Division algorithm, Euclidean algorithm, Diophantine equations, counting techniques.
3. Algebra: polynomials, their structure and arithmetic, division algorithm.
4. Solving equations: linear, quadratic, etc., using complex numbers.
5. Introduction to mathematical induction.
6. Applications: modeling real-world topics.
7. Problem solving (a theme throughout the course).

Catalog Description:
Geometry for middle school teachers.

Purpose of Course:
The purpose of the course is to prepare teachers of middle school students. In particular, it intends to deepen and extend the prospective teachers' content knowledge of the mathematics they will teach as well as their ability to reason with and communicate that knowledge.

Prerequisite:
C- or better in 1165, and enrollment in Middle Childhood Education major with Math as an Area of Concentration.

Follow-up Courses:
Math 2167 and Math 2168

Text:
Course Notes.

Topics List:
1. Visual reasoning via "proofs without words." Measurement (also teaching measurement in middle school)
2. Geometric constructions, congruence, similarity, and problem solving.
3. Coordinate geometry with emphasis on solving equations.
4. Non-Euclidean geometries.
5. Geometric transformations coordinate geometry, complex numbers.
6. Scaling and relationship between perimeter and area.
7. Measurement issues.
8. Modeling real-world situations.

Catalog Description:
Techniques of integration, Taylor series, differential calculus of several variables.

Prerequisite:
C- or better in 1141, 1151, 1156, 152.xx, 161.xx or 161.01H; or 114 or 1114.

Exclusions:
Not open to students in math, pre-actuarial science, or actuarial science. Not open to students with credit for any higher numbered math class, or for 1152; or for 254.xx or higher numbered math class.

Text:
Calculus II developed by Ximera

Topic List:

- A Review of Integration
- Area Between Curves
- Accumulated Cross Sections
- Solids of Revolution
- Length of Curves
- Physical Applications
- Integration by Parts
- Trigonometric Integrals
- Trigonometric Substitution

Midterm 1

- Partial Fractions
- Improper Integrals
- Sequences
- Limits of Sequences
- Sums of Sequences
- Divergence Test
- Ratio Test
- Remainders
- Approximating Functions with Polyn
- Power Series
- Introduction to Taylor Series
- Calculus and Taylor Series

Midterm 2

- Parametric Equations
- Introduction to Polar Coordinates
- Calculus in Polar Coordinates
- Vectors
- Dot Products & Projections
- Cross Products
- Lines and Curves in Space
- Calculus of Vector Valued Functions
- Unit Tangent and Normal Vectors
- Motion In Space & Parameterization by Arclength

Midterm 3

- Planes in Space
- Functions of Several Variables
- Limits and Continuity
- Partial Derivatives and the Gradient
- Differentiability & Tangent Planes
- Chain Rule & Directional Derivatives
- Interpreting the Gradient

Final

Catalog Description:
Single variable calculus treated in depth.

Prerequisites:
1151 or 151.xx, and permission of department.

Exclusions:
Not open to students with credit for any higher numbered math class.

Text:
Calculus with Analytic Geometry, 2nd edition, by Simmons, published by McGraw-Hill,
ISBN: 9780070576424

Topics:

2.1	The Problem of Tangents
2.2	How to Calculate the Slope of the Tangent
2.3	The definition of the Derivative
2.4	Velocity and Rate of Change
2.5	The Concept of a Limit; Two Trigonometric Limits
A2	Theorems about Limits;
3.1	Derivatives of Polynomials
3.2	The Product and Quotient Rules
3.3	Composite Functions and the Chain Rule
3.4	Some trig Derivatives;
3.5	Implicit Functions and Fractional Exponents
3.6	Derivatives of Higher Order
12.2	Indeterminate Form 0/0, L'Hopital's Rule
4.1	Increasing and Decreasing Functions, Maxima and Minima
4.2	Concavity and Points of Inflection
4.3	Applied Maxima and Minima Problems
4.4	Reflection & Refraction
4.5	Related Rates
2.6	Continuous Functions
A4	The Mean Value Theorem
	Midterm I
5.2	Differentials and Tangent Line Approx'n
5.3	Indefinite Integrals, Integration by Substitution;
5.4	Differential Equations, Separation of Variables
6.1	Introduction
6.2	The Problem of Areas.
6.3	The Sigma Notation and Certain Special Sums
6.4	Area under a Curve, Definite Integrals, Riemann
6.5	The Computation of Areas as Limits;
6.6	The Fundamental Theorem of Calculus

6.7	Algebraic and Geometric Areas
7.2	Area between Two Curves;
7.3	Volumes: The Disk Method
7.4	Volumes: The Method of Cylindrical Shells
7.5; 7.6	Arc Length; Area of a Surface of Revolution
7.7	Work and Energy
8.2	Review of Exponents and Logarithms;
8.3	The number e and the function y=e^x
8.4	The Natural Logarithm Function, Euler
8.5	Applications, Population Growth and Radioactive Decay
9.1; 9.2	Review of Trig.; Der've and Integrals of Sin and Cos
9.3; 9.4	Der've of the Other Four Fns
9.5	The Inverse Trig Functions
9.6; 9.7	Simple Harmonic Motion; (“Optional”) Hyperbolic Functions

MIDTERM 2

10.1; 10.2	Basic Formulas; Method of Substitution
10.3: 10.4	Certain Trig Integrals; Trig Substitutions;
10.5; 10.6	Completing the Square
10.7	Integration by Parts
10.8	Strategy for Dealing with Integrals
12.2; 12.3	Indeterminate Form 0/0, L'Hopital's Rule; Other Indeterminate Forms
12.3; 12.4	Improper Integrals
13.1	What is an Infinite Series?;
13.2	Convergent Sequences
13.3	Convergent and Divergent Series
13.4	General Properties of Convergent Series
13.5	Series of Non-negative Terms, Compar. Tests
13.6	Integral Test, Euler's Constant
13.7	Ratio and Root Test
13.8	Alternating Series Test, Absolute Convergence

MIDTERM 3

14.2	The Interval of Convergence
14.3	Differentiation and Integration of Power Series
14.4	Taylor' Series and Taylor's Formula
14.5	Computations Using Taylor's Formula
14.6	Applications to Differential Equations
14.8	Operations on Power Series

FINAL

Prerequisite:
Permission of Department.

Catalog Description:
An advanced enrichment course for interested and capable students.

Purpose of Course:
To offer an experience in problem solving in mathematics for interested and talented students beyond what they would encounter in a standard program. It is preparation for the National Putnam Mathematics Exam. This course is repeatable to a maximum of 6 credit hours, and is graded S/U. This course may not be counted in a major or minor program in Mathematics.

Topics:
Interesting special problems as chosen by the instructor.

Mathematics 1295
Introductory Seminar
Autumn, Spring
1 credit

Catalog Description:
Seminar on mathematical topics for beginning math and actuarial science majors.

Prerequisite:
Enrollment in math or actuarial science major, or permission of department.

Topics List:

1. Overview of the scope of mathematics, its subfields, and its applications.
2. Discussion of the OSU math major and differences among the tracks.
3. Outline of programs and activities that can benefit math majors.
4. Presentation of various different sorts of career opportunities for math majors.

Catalog Description:
This is one of two independent courses which follow Measurement and geome-try for teachers to provide necessary content for middle grade teachers. This course focuses on algebra, coordinate geometry, and their connections through equations in one or more unknowns. Modern and historical perspectives are woven throughout.

Prerequisite:
A grade of C- or above in "Measurement and Geometry for Teachers" (Math 1136). A grade of C-or above in Math 1149 or 1150, or credit for 150, or math placement level L.

Text:
Basic Mathematics, by Serge Lang, Springer, ISBN 9780387967875

Purpose:
This course integrates the various types of numbers introduced in the previous course to present them as members of a single (real) number system. The notion that new numbers are discovered as solutions to equations is promoted, and motivated by connecting various equations with mathematical models.

Matrices are introduced and used as linear transformations, mainly in the plane. The complex numbers are introduced as general solutions to quadratic equations and the relationship between complex arithmetic and transformations in the plane is explored.

The course finishes with several weeks of geometry content for middle grade teachers, including more material on proofs, triangle congruence, and non-Euclidean geometry. The main example is "Taxicab geometry", based on the l_1 norm.

Topics List:
1. Polynomial arithmetic as "base-x" and binomial theorem
2. Real number system
3. Polynomial equations and their roots
4. Exponential and logarithm functions
5. Complex numbers
6. Matrices
7. Complex arithmetic and linear transformations in the plane
8. Geometry proofs
9. Taxicab geometry

Catalog Description:
This is one of two independent courses which follow "Measurement and Geometry for Teachers" (Math 1136) to provide necessary content for middle grade teachers. This course focuses on functions and calculus, including modern and historical perspectives.

Prerequisite:
A grade of C- or above in "Measurement and Geometry for Teachers" (Math 1136). A grade of C- or above in Math 1149 or 1150, or credit for 150, or math placement level L.

Text:
Calculus, by Frank Morgan, CreateSpace Independent Publishing Platform, ISBN 9781478356882

Purpose:
This course serves to introduce students to the key ideas of calculus and to important historical developments in the subject. A thorough introduction to functions as mappings is given, and the trigonometric functions are used throughout the course as a key example of functions not given by algebraic expressions.

The essential concepts of limit, derivative, integral, and the fundamental theorem are emphasized, together with core applications. An introduction to Taylor series, especially the Taylor expansions for sine and cosine, completes the class.

Topics List:
1. Functions
2. Elementary approach to how functions change
3. Defining rate of change
4. Concept of limit
5. Derivatives
6. Interpretations of first and second derivatives
7. Sine, cosine and logarithm functions
8. Product rule and chain rule
9. Applications of derivatives
10. Antiderivatives
11. Riemann sums
12. Fundamental theorem of calculus
13. Applications of integration
14. Taylor approximations, infinite sequences
15. Series

Catalog Description:
Multivariable differential and integral calculus.

Prerequisites:
C- or better in 1152, 1172, 1534, 1544, 1181H, or 4181H; or credit for 153.xx, 154, 162.xx, or 162.01H.

Exclusions:
Not open to students with credit for any higher numbered math class, or for any quarter math class numbered 254 or higher.

Text:
Calculus for Scientists and Engineers: Early Transcendentals, 2nd OSU custom edition, by Briggs, Cochran, Gillett, published by Pearson, ISBN: 9781256776468

Topics:

CHAPTER 12. Vectors and Vector-Valued Functions
- Section 1. Vectors in the Plane
- Section 2. Vectors in Three Dimensions
- Section 3. Dot Products
- Section 4. Cross Products
- Section 5. Lines and Curves in Space
- Section 6. Calculus of Vector-Valued Functions
- Section 7. Motion in Space
- Section 8. Length of Curves
- Section 9. Curvature and Normal Vectors

CHAPTER 13. Functions of Several Variables
- Section 1. Planes and Surfaces, and brief conic section review
  via pages 761 to 766 of Section 11.4
- Section 2. Graphs and Level Curves
- Section 3. Limits and Continuity
- Section 4. Partial Derivatives
- Section 5. The Chain Rule
- Section 6. Directional Derivatives and the Gradient
- Section 7. Tangent Planes and Linear Approximation
- Section 8. Maximum/Minimum Problems
- Section 9. Lagrange Multipliers

CHAPTER 14. Multiple Integration
- Section 1. Double Integrals over Rectangular Regions
- Section 2. Double Integrals over General Regions
- Section 3. Double Integrals in Polar Coordinates
- Section 4. Triple Integrals
- Section 5. Triple Integrals in Cylindrical and Spherical Coordinates
- Section 6. Integrals for Mass Calculations
- Section 7. Change of Variables in Multiple Integrals

CHAPTER 15. Vector Calculus
- Section 1. Vector Fields
- Section 2. Line Integrals
- Section 3. Conservative Vector Fields
- Section 4. Green's Theorem
- Section 5. Divergence and Curl
- Section 6. Surface Integrals
- Section 7. Stokes' Theorem
- Section 8. Divergence Theorem

Catalog Description:
Multivariable calculus; introduction to Taylor series. This course is discontinued for 2021-2022.

Prerequisites:
C- or better in 1161.xx or 1181H.

Exclusions:
For 2162.01: Not open to students with credit for any higher numbered math class numbered 2162 or higher.
For 2162.02: Intended for students in Freshman Engineering Honors and not open to students with credit for any higher numbered math class numbered 2162 or higher.

Text:
Calculus for Scientists and Engineers: Early Transcendentals, 2nd OSU custom edition, by Briggs, Cochran, Gillett, Person, published by Pearson, ISBN: 9781269753449

Topics:

9.1; 9.2	An Overview; Sequences
9.2; 9.3	Sequences; Infinite Series
9.4	Divergence and Integral Tests
9.5	Ratio, root, and Comparison Tests
9.5; 9.6	Ratio, root, and Comparison Tests; Alternating Series;
10.1; 10.2	Approximating Functions with Polynomials; Properties of power Series
10.3; 10.4	Taylor Series; Working with Taylor Series
11.1; 11.2	Parametric Equations; Polar Coordinates
11.2; 11.3	Polar Coordinates; Calculus in Polar Coordinates
	Midterm 1

12.1; 12.2	Vectors in the Plane; Vectors in Three Dimensions
12.3;12.4	Dot Products; Cross Products
12.5	Lines and Curves in Space
12.6	Calculus of Vector-Valued Functions
12.7; 12.8	Motion in Space; Length of Curves
12.9	Curvature and Normal Vectors
13.1; 13.2	Planes and Surfaces; Graphs and Level Curves
13.3	Limits and Continuity
13.4;13.5	Partial Derivatives; Chain Rule
13.6	Directional derivative and the Gradient
	MIDTERM 2
13.7	Tangent Plane and Linear Approximation
13.8	Maximum/Minimum Problems
13.9	Lagrange Multipliers
14.1; 14.2	Double Integral over Rectangular Regions; Double Integrals over General Regions
14.2; 14.3	Double Integrals over General Regions; Double integrals in Polar Coordinates
14.4; 14.5	Triple Integrals; Triple Integrals in Cylindricals and Sphericals
14.5; 14.6	Triple Integrals in Cylindricals and Sphericals; Integrals for Mass Calculations
15.1	Vector Fields
15.2	Line Integrals
15.3	Conservative Vector Fields
	MIDTERM 3
15.4	Green's Theorem
15.5	Divergence and Curl
15.6	Surface Integrals
15.7	Stokes' Theorem
15.8	Divergence Theorem

Catalog Description:
Concepts of Calculus for Middle School Math teachers.

Prerequisite:
A grade of C- or above in 1165, or credit for 1164 or 110; and enrollment in Middle Childhood Education major or pre-major with Math as area of concentration.

Exclusions:
Not open to students with credit for 111.

Purpose of Course:
The purpose of the course is to prepare teachers of middle school students. In particular, it intends to deepen and extend the prospective teachers' content knowledge of the mathematics and mathematical reasoning that they will teach as well as their ability to reason with and communicate that knowledge.

Follow-up Courses:
Math 2168

Text:
Under Consideration.
Optional text: ***Calculus Connections: Mathematics for Middle School Teachers***. By Asma Harcharras and Dorina Mitrea (2007). Published by Prentice Hall. ISBN: 0-13-144923-0
Supplementary Text: Course Notes

Topics List:
1. Rates described pictorially, in writing, and with symbols.
2. Informal and formal measurement of (instantaneous) rates and their connection to middle school mathematics.
3. Informal and formal measurement of (accumulated) areas and their connection to middle school mathematics.
4. The Fundamental Theorem of Calculus.
5. Applications of differential calculus.
6. Applications of integral calculus.

Catalog Description:
Historical and mathematical discussion of topics in the middle school math curriculum.

Prerequisite:
C- or better in 2167; or credit for 111. Limited to Middle Childhood majors and pre-majors with Math as an Area of Concentration.

Purpose of Course:
The purpose of the course is to prepare prospective middle school math teachers. In particular, it intends to deepen and extend prospective teachers' connections among topics in mathematics through the study of the history of mathematics, as well as continuing to develop their ability to reason with and communicate that knowledge.

Follow-up Courses:
None

Text:
Math through the Ages: A Gentle History for Teachers & Others, Expanded Edition, by Berlinghoff & Bouvea, published by Mathematical Association, ISBN: 9780883857366

Course Packet

Topics List:

1. History of Mathematics, from ancient to modern times.
2. Development of number systems, operations, geometry, trigonometry, algebra, calculus, statistics, and probability.
3. Applications: modeling real-world topics.
4. Problem solving (a theme throughout the course).

Catalog Description:
Multiple integrals, line integrals, vector fields, second order ordinary differential equations.

Prerequisite:
Math 1172, 1544, or 154.

Exclusions:
Not open to students with credit for 1152, 2153, or for any higher numbered math class, or for any quarter-system math class numbered 254 or higher.

Text:
Calculus for Scientists and Engineers: Early Transcendentals, 2nd OSU custom edition, by Briggs, Cochran, Gillett, published by Pearson, ISBN: 9781269753449

Topics List:

13.6	(Review of) Directional Derivatives and the Gradient Vector
13.8	Maximum and Minimum Values
13.9	Lagrange Multipliers
14.1	Double Integrals over Rectangular Regions
14.2	Double Integrals over General Regions
14.3	Double Integrals in Polar Coordinates
	Midterm 1
14.4	Triple Integrals
14.5	Triple Integrals in Cylindrical & Spherical Coordinates
14.7	Change of Variables in Multiple Integrals
15.1	Vector Fields
15.2	Line Integrals
15.3	Conservative Vector Fields
	Midterm 2
16.1	Basic Ideas of Second Order ODE's
Appendix C	Complex Arithmetic
16.2	Linear Homogeneous Equations
16.3	Linear Homogeneous Equations
16.4	Applications; Complex Forcing Functions
	Final

Catalog Description:
Matrix theory, eigenvectors and eigenvalues, ordinary and partial differential equations.

Prerequisite:
2173 and either major in ENG, Physics, or Chemistry or permission of math department.

Exclusions:
Not open to students with credit for both (i) 2415 (415) or 2255 (255) and (ii) 2568 (568 or 571).

Text:

Part II: Elementary Ordinary & Partial Differential Equations, OSU custom edition, by Boyce, published by Wiley, ISBN: 9781119934462
Introduction to Linear Algebra, 5th edition, by Johnson, Riess and Arnold, published by Pearson, ISBN: 9780321628217

Topics List:

Part One = Matrix Algebra
Textbook sections from Arnold, Riess, and Johnson's *Introduction to Linear Algebra*, 5th edition
Chapter 1: Matrices and Linear Systems of Equations
Chapter 3: The Vector Space $\mathbb{R}^n$
Chapter 4: The Eigenvalue Problem

1.1 Introduction and Gaussian Elimination and Systems of Linear Equations
1.2 Echelon Form and Gauss-Jordan Elimination
1.3 Consistent Systems of Linear Equations
1.5 Matrix Operations
1.6 Algebraic Properties of Matrix operations
1.7 Linear Independence and Nonsingular Matrices
1.9 Matrix Inverses and the Properties
3.1-3.2 Review and Vector Space Properties in $\mathbb{R}^n$
3.3 Examples of Subspaces
3.4 Basis for Subspaces; Dimension

Midterm I

4.1 The Eigenvalue Problem for 2x2 Matrices
4.2 Determinants and the eigenvalue Problem
4.4 Eigenvalues and characteristic Polynomial
4.5 Eigenvectors and Eigenspaces
4.6 Complex Eigenvalues and Eigenvectors
4.7 Similarity Xformations and Diagonalization

Part Two = Systems of Linear Differential Equations
Textbook Sections from Boyce & DiPrima's *Part II: Elementary Ordinary & Partial Differential Equations*

Ch. 7: Systems of First Order Linear Equations (no lectures, but assigned as an independent class project)

Midterm 2

Part Three = Partial Differential Equations and Fourier Series
Textbook Sections from Boyce & DiPrima's *Part II: Elementary Ordinary & Partial Differential Equations*

10.1 Two point Boundary Value Problem
10.2 Fourier Series
10.3 The Fourier Convergence Theorem
10.4 Even and Odd Functions
10.5 Separation of Variables; Heat Conduction Equation
10.6 Other Heat Conduction Problems
10.7 The Wave Equation; Vibrations of an Elastic String
10.8 Laplace's Equation (optional)

Catalog Description:
Multiple integrals, line integrals; matrix algebra; linear (ordinary and partial) differential equations.

Prerequisite:
Major, pre-major, or minor in BiomedE, CEEGS, FABEng, MatScEn, CBE, or WeldEn; and: 1172, 2153, 1544 (154), 254.xx, 263.xx, 263.01H, or 264H

Exclusions:
Not open to students with credit for 2174 or 5520H; or with credit for both (i) 2415 (415), 2255 (255) or 4512 (512) and (ii) 2568 (568 or 571).

Text:
Math 2177, Custom Edition for OSU, Pearson, ISBN-13 978-1-256-82676-7 or ISBN-10 1-256-82676-6 **–OR**– the textbooks listed below.

Topics List:

PART ONE: Multivariable Integral Calculus
Textbook Sections from *Calculus for Scientists and Engineers: Early Transcendentals*, by Briggs, Cochran, Gillett and Shulz, Chapters 13-15

2177 Custom	Original Text	Topic
1.8	13.8	Maximum/Minimum Problems
1.9	13.9	Lagrange Multipliers
2.1	14.1	Double Integrals over Rectangular Regions
2.2	14.2	Double Integrals over General Regions
2.3	14.3	Double Integrals in Polar Coordinates
2.4	14.4	Triple Integrals
2.5	14.5	Triple Integrals in Cylindrical and Spherical Coordinates
2.7	14.7	Change of Variables in Multiple Integrals
3.1	15.1	Vector Fields
3.2	15.2	Line Integrals
3.3	15.3	Conservative Vector Field

Midterm 1

PART TWO: Matrices and Linear Systems of Equations
Textbook Sections from *Introduction to Linear Algebra*, by Johnson, Riess, and Arnold, 5th edition, Chapter 1: Matrices and Systems of Linear Equations

2177 Custom	Original Text	Topic
4.1	1.1	Introduction to Matrices and Systems of Linear Equations
4.2	1.2	Echelon Form and Gauss-Jordan Elimination
4.3	1.3	Consistent Systems of Linear Equations
4.4	4.4	Applications (optional)
4.5	1.5	Matrix Operations
4.6	1.6	Algebraic Properties of Matrix operations
4.7	1.7	Linear Independence and Nonsingular Matrices
4.8	1.8	Data Fitting, Numerical Integration and Numerical Differentiation
Midterm 2		

PART THREE: 2nd Order Constant Coefficient O.D.E.' s
Textbook Sections from *Calculus for Scientists and Engineers: Early Transcendentals*, by Briggs, Cochran, Gillett and Shulz, Chapter 16 and Appendix C

2177 Custom	Original Text	Topic
5.1	16.1	Basic Ideas
Appx C	Appx C	Complex Numbers
5.2	16.2	Linear Homogeneous Equations
5.3	16.3	Linear Nonhomogeneous Equations
5.4	16.4	Applications
Midterm 3		

PART FOUR: Fourier Series & Partial Differential Equations
Textbook Sections from *Fundamentals of Differential Equations and Boundary Value Problems*, by Nagle, Saff and Snider, 8th Edition, Chapter 10

2177 Custom	Original Text	Topic
6.1	10.1	Introduction: A Model for Heat Flow
6.2	10.2	Method of Separation of Variables
6.3	10.3	Fourier Series
6.4	10.4	Fourier Cosine and Sine Series
6.5	10.5	The Heat Equation
6.6	10.6	The Wave Equation

Catalog Description:
Multivariable calculus treated in depth.

Prerequisite:
C or better in 1181H or 4181H.

Exclusions:
Not open to students with credit for both 162.01H and 263.01H

Text:
Calculus with Analytic Geometry, 2nd Edition, by George F. Simmons, published by McGraw-Hill, ISBN: 0070576424

Topics List:

15.1; 15.2	Conic sections: Ellipse, Parabola, Hyperbola
15.3; 15.4	Conic sections: Ellipse, Parabola, Hyperbola
16.1	Polar coordinate system
16.2	Graphs of polar equations
16.3	Polar Equations of conics and spirals
16.3; 16.4	Polar Equations of conics and spirals; Arc length and tangent lines
16.5	Areas in polar coordinates
17.1	Parametric Equations of Curves
17.2	Cycloids and other similar Figures
17.3	Vector Algebra, the Unit Vectors *i* and *j*;
17.4	Derivatives of Vector Functions, Velocity and Acceleration
17.5	Curvature and the Unit Normal Vector
17.6	Tangential and Normal Components of Acceleration
17.7	Kepler's Laws and Newton's Law of Universal Gravitation
	Midterm 1

18.1	Coordinates and Vectors in 3-D Space
18.2	The Cross Product of Two Vectors
18.3	The Dot Product of Two Vectors
18.4	Lines and Planes
18.5	Cylinders and Surfaces of Revolution
18.6	Quadratic Surfaces;
18.7	Cylindrical and Spherical Coordinates
19.1	Function of Several Variables
19.2	Partial Derivatives
19.3	The Plane Tangent to a Surface
19.4	Increments and Differentials, the Fundamental Lemma
19.5	Directional Derivatives and the Gradient
19.6	The Chain Rule for Partial Derivatives
19.7; 19.8	Maximum and Minimum Problems
19.10	Implicit Functions

Midterm 2

20.1	Volumes as Iterated Integrals
20.2	Double Integrals and Iterated Integrals
20.3	Physical Applications of Double Integrals
20.4	Double Integrals in Polar Coordinates
20.5	Triple Integrals
20.6	Cylindrical Coordinates
20.7	Spherical Coordinates, Gravitational Attraction
20.8	Area of Curved Surfaces

Midterm 3

21.1	Line Integrals in the Plane
21.2	Independence of Path, Conservative Fields
21.3	Green's Theorem
21.4	Surface Integrals and Gauss' Theorem
21.5	Stokes' Theorem

Catalog Description:
Ordinary differential equations, their series solutions, numerical methods, Laplace transforms, physical applications.

Prerequisite:
C- or better in 2153, 2162.xx, 2173, 2182H, or 4182H; or credit for 254.xx, 263.xx, 263.01H, or 264H.

Text:
Ordinary Differential Equations and their Applications, OSU custom edition, by Boyce, published by Wiley, ISBN 9781119934455

Topics List:

INTRODUCTION
1.3 Classification of Differential Equations
2.1 Linear Equations with Variable Coefficients

FIRST ORDER DIFFERENTIAL EQUATIONS
2.2 Separable Equations
2.4 Differences between Linear and Nonlinear Equations
2.5 Autonomous Equations and Population Dynamics
2.6 Exact Equations and Integrating Factors
2.7 Numerical Approximations: Euler's Method
2.8 The Existence and Uniqueness Theorem
2.9 First Order Difference Equations

SECOND ORDER LINEAR EQUATIONS
3.1 Homogeneous Equations with Constant Coefficients
3.3 Complex Roots of the Characteristic Equation
3.2 Solutions of Linear Homogeneous Equations; the Wronkian
3.4 Repeated Roots; Reduction of Order

Midterm 1

3.5 Nonhomogeneous Equations; Method of Undetermined Coefficients
3.6 Variation of Parameters
3.7 Mechanical and Electrical Vibrations
3.8 Forced Vibrations

THE LAPLACE TRANSFORM

6.1 Definition of the Laplace Transform
6.3 Step Functions
6.2 Solution of Initial Value Problems
6.4 Differential Equations with Discontinuous Forcing Functions
6.5 Impulse Functions
6.6 The Convolution Integral

Midterm 2

HIGHER ORDER LINEAR EQUATIONS

4.1 General Theory of nth Order Equations
4.2 Homogeneous Equations with Constant Coefficients
4.3 The Method of Undetermined Coefficients Material
4.4 The Method of Variation of Parameters

SERIES SOLUTIONS OF SECOND ORDER LINEAR EQUATIONS

5.1 Review of Power Series
5.2 Series Solutions near an Ordinary Point, Part I
5.3 Series Solutions near an Ordinary Point, Part II
5.4 Euler's Equation; Regular Singular Points

Midterm 3

5.5 Series Solutions near a Regular Singular Point, Part I
5.6 Series Solutions near a Regular Singular Point, Part II
5.7 Bessel's Equation

Catalog Description:
Mathematical reasoning, logic, sets, functions, recursive definitions, elementary counting principles.

Prerequisites:
C- or better in 1131 or 1151; credit for 132 or 152.xx; or permission of department.

Exclusions:
Open only to majors in MIS (Management Information Systems). Not open to students with credit for 366.

Text:
Discrete Mathematics with Applications, 4th edition, by Epp, published by Cengage, ISBN: 9780495391326, Lecture Notes by G. Baker.

Topics List:
Topics for this discrete math course depend on future discussions with colleagues in Management Information Systems.

Catalog Description:
Ordinary and partial differential equations: Fourier series, boundary and initial value problems.

Prerequisite:
2153, 2162.xx, 2173, 2182H, 4182H, both (1172 or 1544 or 154) **and** 2568, 254.xx, 263.xx, 263.01H, or 264H.

Exclusions:
Not open to students with credit for Math 2255, 5520H, 2174, 255, 415.xx, or 521H.

Textbook:
Elementary Differential Equations and Boundary Value Problems, 10th Edition, by W. Boyce and R. DiPrima, ISBN 978-1-118-15738-1
-or- Lectures Notes, by Greg Baker, published by Zip Printing.

Topics List:
1.1 Some Basic Mathematical Models & Direction Fields
1.3 Classification of Differential Equations
1.2 Solutions to some Differential Equations
2.2 Separable Equations
2.1 Linear Equations with Variable Coefficients
2.3 Modeling with First Order Differential Equations
2.4 Difference between Linear and Nonlinear Equations
2.5 Autonomous Equations and Population Dynamics
3.1 Homogeneous Equations with Constant Coefficients;
3.3 Complex Roots of the Characteristic Equation
3.4 Repeated Roots

Midterm 1

3.2 Solutions of Linear Homogeneous Equations; the Wronskian
3.4 Reduction of Order
4.5 Non-homogeneous Equations; Method of Undetermined Coefficients
3.7 Mechanical and Electrical vibrations
3.9 Forced Vibrations
10.1 Two-point Boundary Value Problem

Midterm 2

10.2 Fourier Series
10.3 The Fourier Convergence Theorem
10.4 Even and Odd Functions
10.5 Separation of Variables; Heat Conduction in a Rod
10.7 Wave Equation: Vibrations of an Elastic String
7.1 Introduction
7.3 Systems of Linear Algebraic Equations; Linear Independence, Eigenvalues, Eigenvectors
7.5 Homogeneous Linear Systems with Constant Coefficients
7.6 Complex Eigenvalues
7.4 Basic Theory of Systems of 1st Order Linear Equations

Catalog Description:
Matrix algebra, vector spaces and linear maps, bases and dimension, eigenvalues and eigenvectors, applications.

Prerequisite:
C- or above in 1172, 1544, 2153, 2162.xx, 2182H, or 4182H; or C- or above in both 1152 and CSE 2321; or credit for 154, 254.xx, 263.xx, 263.01H, or 264H.

Exclusions:
Not open to students with credit for 4568 (568), 5520H (520H), or 572.

Text:
Introduction to Linear Algebra, 5th edition, by L.W. Johnson, R.D. Riess, and J.T. Arnold, published by Pearson, ISBN Softcover: 0321628217, Hardcover: 0201658593

Topics List:

Part I

1.1 Introduction to Matrices and Systems of linear equations
1.2 Echelon Form and Gaussian-Jordan Elimination
1.3 Consistent Systems of linear Equations
1.5 Matrix Operations
1.6 Algebraic Properties of Matrix operations
1.7 Linear Independence and Nonsingular Matrices
1.9 Matrix Inverses and Their Properties

Midterm 1

Part II

2.1 Vectors in The Plane (Review only because it was done in 1152)
2.2 Vectors in Space (Review only because it was done in 1152)
2.3 The Dot Product and The Cross
3.1 Introduction
3.2 Vector Space Properties of $\mathbb{R}^n$
3.3 Examples of Subspaces
3.4 Bases for Subspaces
3.5 Dimension
5.2 Vector Spaces
5.3 Subspaces
5.4 Linear Independence, Bases, and Coordinates
3.6 Orthogonal Bases for Subspaces
3.7 Linear Transformation from $\mathbb{R}^n$ to $\mathbb{R}^m$

Midterm 2

Part III

4.1 The Eigenvalue Problem for 2x2 Matrices
4.2 Determinants and the Eigenvalue Problem
4.4 Eigenvalues and Characteristic Polynomial
4.5 Eigenvectors and Eigenspaces
4.6 Complex Eigenvalues and Eigenvectors
4.7 Similarity Transformations and Diagonalization

Final

Catalog Description:
Introduction to logic, proof techniques, set theory, number theory, real numbers.

Prerequisite:
Major or minor in Math, CSE, or CIS.

Math: C- or better in 2153, 2162.xx, 2173, or 2182H; or credit for 254.xx, 263.xx or 263.01H.

CIS or CSE:
C- or better in both CSE 2321 and: C- or better in 1152, 1161.xx, 1172, 1181H, 1534, or 1544; or credit for 153.xx, 154, 162.xx, or 162.01H.

Exclusions:
Not open to students with credit for 345.

Text:
Lecture Notes, by N. Falkner.

Topics List:
1. Propositional calculus; quantifiers.
2. Simple examples of mathematical proofs.
3. Mathematical induction.
4. Sets and functions: surjections, injections, bijections.
5. Infinite sets: countable and uncountable.

Catalog Description:
Introduction to quantitative and qualitative analysis of several mathematical models for biological systems.

Purpose:
This course provides students with experience and knowledge in mathematical analysis of differential equations models, as well as with numerical tools for simulating those models.

Prerequisite:
C- or better in Math 2255, 2415, 5520H; or credit for 255, 415.xx, or 521H.

Text:
Lecture Notes

Topics List:
1. Population dynamics: Logistic growth.
2. Population dynamics: Lotka-Volterra predator-prey model.
3. Modeling specific diseases (e.g. HIV, cancer).
4. Competition models.
5. Dynamics of neurons.
6. Bifurcution theory.
7. Enzyme kinetics.
8. Cells proliferation and death.

Catalog Description:
Problem workshop for applications of calculus and probability to actuarial science and risk management.

Prerequisite:
C- or better in Math 4530, 5530H, or Stat 4201; or credit for 530, 531H, or Stat 420.

Topics List:
1. Random variables.
2. Discrete distributions.
3. Continuous distributions.
4. Central Limit Theorem and law of large numbers.
5. Risk models.

Catalog Description:
Presentations by practicing actuaries on topics drawn from their fields of expertise; oral presentations by students on selected topics in actuarial science.

Prerequisite:
3rd year standing and completion of second writing course.

Exclusions:
Open only to actuarial science majors.

Text:
None.

Topics List:
1. Business communication.
2. Problems in life insurance.
3. Problems in property and casualty insurance.
4. Problems in pension consulting.
5. Problems in health care consulting.
6. Risk management.

Catalog Description:
Introduction to mathematics used in financial asset pricing, based on the binomial asset pricing model. This course prepares students for further study of stochastic calculus in continuous time.

Purpose:
This course is designed as an introduction to the concepts encountered in financial mathematics for students who don't have a background in continuous-time stochastic calculus.

Prerequisite:
{C- or better in 3345 or credit for 345}; and {C- or better in 4530, 5530H, or Stat 4201, or credit for 530, 531H, 345 or Stat 420}; or permission of department.

Text:
Stochastic Calculus for Finance I, The Binomial Asset Pricing Model, by Shreve, published by Springer, ISBN: 9780387249681

Topics List:
1. First principles; assumptions about stock behavior and description of basic financial instruments; put and call options.
2. Arbitrage, and no-arbitrage pricing.
3. One-period and multi-period models; replication and hedging.
4. Conditional expectations.
5. Martingales and Markov processes.
6. Change of measure.
7. Utility functions and the capital asset pricing model.
8. Stopping times and American derivatives.
9. Random walks and passage times.

Catalog Description:
Introduction to uses of computers to solve problems arising in the physical and biological sciences, and in engineering and finance.

Prerequisite:
{C- or better in 2255, 2415, or 5520H; and C- or better in 2568 or 5520H}; or:
{credit for 255, 415.xx, or 521H; and credit for 568, 571, or 520H}.

Purpose:
Math 3607 is a course which has three main goals: it introduces students to MATLAB (or improves their knowledge of MATLAB); it uses MATLAB to solve practical problems from various areas of mathematics, physics, engineering, business, and finance; and it presents the numerical analysis needed to use MATLAB effectively. The principle underlying this course is that the way to learn MATLAB and numerical analysis is by doing it, not by reading about it. This course is taught in a computer lab and MATLAB will be used to some extent every class.

Textbook:
Learning MATLAB, Problem Solving, and Numerical Analysis through Examples, by Ed Overman (downloadable e-book).

Topics List:
1. MATLAB as a scalar calculator, round-off errors, debugging.
2. Arrays in MATLAB, probability theory, Markov processes.
3. Graphics in MATLAB, applications of probability theory, histograms.
4. Programming in MATLAB, more probability theory, mathematical biology.
5. Function m-files in MATLAB, more Markov processes, chaos.
6. More about functions, randomness.
7. Solving linear systems of equations.
8. Interpolation and approximation.
9. The solution of nonlinear equations and unconstrained optimization.
10. Numerical differentiation and integration
11. Time-evolution ordinary differential equations, boundary-value ordinary differential equations, stochastic differential equations, examples from many disciplines.
12. Eigenvalues, Fourier series.

THE OHIO STATE UNIVERSITY

Mathematics 3618
Theory of Interest
Autumn, Spring, Summer
3 credits

Catalog Description:
Financial transactions involving interest: measurement of interest, force of interest, annuities-certain, introduction to financial derivatives.

Prerequisite:
C- or better in 1152, 2162.xx, 1172, 2182H, 4181H; or credit for 153, 162, 162H, or 191H.

Exclusions: Open only to actuarial science majors and pre-majors, and to math majors.

Text:
Mathematics of Investment & Credit, 7th edition, by Broverman, published by Actex. ISBN: 9781635882216
Derivatives Markets, 3rd edition, by McDonald, published by Pearson, ISBN: 9780321543080

Topics List:
1. Compound and simple rates of interest and discount, force of interest.
2. Annuity certain and annuity due.
3. Mortgage amortizations.
4. Evaluation of bonds.
5. Durations.
6. Asset and liability matching.
7. Introduction to options, futures, and other derivatives.

Catalog Description:
4181H and 4182H is an enriched honors sequence introducing students to mathematical underpinnings of calculus. 4181H is the first of the calculus sequence designed to introduce students to the mathematical underpinnings of analysis. 4182H is a continuation with a rigorous treatment of multivariable calculus including gradients, multiple integrals, line and surface integrals, Green's theorem, the divergence theorem, and Stokes' Theorem.

Prerequisite:
4181H: Permission of department.
4182H: B- or better in 4181H, or permission of department.

Purpose of Course:
This two-semester sequence comprises the most intensive first year honors track in mathematics. It is designed to challenge talented, highly motivated students, regardless of their chosen major area of study. The courses introduce students to the mathematical underpinnings of calculus and stimulate the development of mathematical thinking, in addition to covering the material of the traditional calculus sequence. 4181H and 4182H will fulfill the analysis requirement for a Math major. The sequence is taught by faculty members in small sections with considerable teacher-student interaction.

Text:
4181H: *Calculus*, 4th edition, by Spivak, published by Publish or Perish, ISBN: 9780914098918
4182H: *Advanced Calculus*, by Folland, published by Pearson, ISBN: 9780130652652

Topics List:

4181H:
1. Properties of real numbers
2. Mathematical induction
3. Definition of integral
4. Integrals of polynomials and trigonometric functions.
5. Applications
6. Continuity, limits, derivatives and applications
7. Fundamental Theorem of Calculus and integration techniques
8. Taylor series
9. Sequences and series of numbers and functions
10. Uniform convergence
11. Power series
12. If time permits, some differential equations or complex-valued functions.

4182H:

1. Multivariable calculus (vector approach)
2. Gradients
3. Multiple integrals
4. Line and surface integrals
5. Green's Theorem
6. Divergence theorem
7. Stokes' Theorem.

Catalog Description:
Introduction to mathematical modeling and computational analysis of neuronal systems, Hodgkin-Huxley model, dynamical systems methods, neuronal networks, models for neurological disease.

Prerequisite:
Math 1152 (152) or 1157 or permission of instructor.

Text:
Foundations of Mathematical Neuroscience, by G. Bard Ermentrout and David H. Terman

Purpose:
Mathematical models and computational methods have been very useful in understanding biological mechanisms underlying neuronal behavior. The Hodgkin-Huxley model, for example, has formed the basis for our understanding of how action potentials are generated and how they propagate along a nerve axon. More recently, mathematical models have been used to help understand cellular processes responsible for both normal and pathological firing patterns that arise in a wide range of neuronal systems. Examples include models for sensory processing, motor control, neurological disease, sleep rhythms and working memory.

This course provides a detailed introduction to how mathematical and computational methods have been used to both develop and analyze models that arise in neuroscience. We begin by deriving the Hodgkin-Huxley model and then describe dynamical system methods for analyzing models. After discussing the dynamics of single neurons, we consider neuronal networks and describe how different types of population firing patterns depend on biological details, such as the intrinsic properties of individual neurons and synaptic coupling. We conclude by considering specific brain systems.

Topics List:
1. Overview: Neurons, synapses, neuronal firing patterns
2. Hodgkin-Huxley Model: Resting potential, Nernst equation, Goldman-Hodgkin-Katz equation, cable equation, action potential
3. Dynamics I: Introduction to differential equations; phase-planes; oscillations
4. Dynamics II: Stability analysis, bifurcation theory, numerical methods
5. Single cell dynamics I: Propagating action potentials; rhythmic behavior
6. Single cell dynamics II: Variety of channels, bursting oscillations; dendrites; multi-compartment models
7. Synapses: Simple networks
8. Networks: Classification of network behavior; synchrony, role of different types of channels and coupling
9. Specific brain systems: Possible topics include models for working memory, vision, olfaction, sleep, Parkinson's tremor, stroke
10. Presentation of projects

Catalog Description:
Development of mathematics from primitive origins to present forms. Topics include: development of arithmetic, algebra, geometry, trigonometry, and calculus.

Prerequisite:
C- or better in 3345, 4507, or 5520H; or credit for 568, 571, 507, 580, or 520H; or permission of department.

Exclusions:
Open only to math majors, or students with graduate standing in Ed T&L. Not open to students with credit for 504.

Text:
Journey through Genius, by William Dunham, published by Wiley, ISBN: 0471500305, and *Ximera History of Mathematics* (Free online access through Carmen)

Topics List:
1. Development of arithmetic; Babylonian tablets and Egyptian papyri.
2. Development of geometry: Pythagoras, Thales, Euclid, Archimedes, and non-Euclidean geometry.
3. Development of algebra: Arabic scholars, Fibonacci, Cardano.
4. Development of calculus: Newton, Leibniz, Bernoulli, Euler, Gauss.
5. Beyond calculus: Cantor, others by choice of instructor or students.

Catalog Description:
Topics in Euclidean, spherical, and hyperbolic geometries. Connections to high school mathematics, calculus, and the theory of groups are emphasized.

Prerequisite:
C- or better in 3345 and in C- or better in 2568 or 5520H; or credit for 345, and credit for 568, 571, or 520H; or graduate standing.

Text:
Open-source textbook:
A workbook of two-dimensional geometries, Clemens and Snapp.

PDF:
https://github.com/mooculus/advancedGeometry/releases/download/v1.0/workbookOfTwoDimensionalGeometries.pdf

Source: https://github.com/mooculus/advancedGeometry

Purpose:
Starting from questions accessible to Euclid, this course treats Euclidean, spherical, and hyperbolic geometry from a unified point of view.

To encourage the student to become a "do-er" of mathematics, in this course essentially write their own "textbook," as the proofs of a majority of the theorems are left to the student.

Topics List:
1. Neutral geometry.
2. Euclidean geometry.
3. Spherical geometry.
4. Hyperbolic geometry.

THE OHIO STATE UNIVERSITY

Mathematics 4512
Partial Differential Equations
for Science and Engineering
Autumn, Spring, Summer
3 credits

Catalog Description:
Second-order PDEs; boundary value problems; Fourier series; wave, heat and Laplace equations; applications.

Prerequisite:
C- or better in 2173, 2153, 2162.xx, 2182H, or 4182H; or credit for 254.xx, 263.xx, 263.01H, or 264H. Intended for undergraduate and master degree students in Engineering and Science.

Exclusions:
Not open to students with credit for 4557, 512, or 557.
Not open to students with a math major, math minor or actuarial science major.

Purpose of Course:
This course develops problem solving skills with little emphasis on theory. Students should be able to solve the PDE's and ODE's and interpret the solution.

Text:
Partial Differential Equations & Boundary Value Problems, 11th OSU Custom Edition, by Boyce, published by Wiley, ISBN: 9781119805113
This text is only available as an eBook

Link for students to buy the eText:

https://www.vitalsource.com/products/partial-differential-equations-amp-boundary-value-william-e-boyce-v9781119805113?term=9781119805113

Topics List:

Part I: ODE's via The Laplace Transform (Chapter 6); Euler's and Bessel's Equation (½ of Chapter 5)

6.1 Definition of the Laplace Transform
6.2 Solution of Initial Value Problems
6.3 Step Functions
6.4 Differential Equations with Discontinuous Forcing Functions
6.5 Impulse Functions
6.6 Convolution Integral
5.4 Euler's Equation; Regular Singular Points
5.5 Series Solution near a Singular Point: Part I
5.6 Series Solution near a Singular Point: Part II
5.7 Bessel's Equation

Midterm I

Part II: Partial Differential Equations and Fourier Series (Chapter 10)

10.1 The Two-Point Boundary Value Problem
10.2 Fourier Series
10.3 Fourier Convergence Theorem
10.4 Even and Odd Functions
Appendix A Heat Conduction Equation: Motivation via Derivation
10.5 Separation of Variables; Heat Conduction in a Rod
10.6 Other Heat Conduction Problems: Nonhomogeneous, Mixed Boundary Conditions
Appendix B Wave Equation: Motivation via Derivation;
10.7 Vibrations of an Elastic String
10.8 Laplace's Equation: Separation in Cartesian Coordinates Dirichelet vs. Neumann Boundary Conditions
10.8 Separation and Solution in Polar and Cylindrical Coordinates

Midterm II

Part III: Boundary Value Problems (Chapter 11)

11.1 Two-point Boundary Value Problems
11.2 Sturm-Liouville Boundary Value Problems I
11.2 Sturm-Liouville Boundary Value Problems II
11.3 Nonhomogeneous Boundary Value Problems
11.4 Singular Sturm-Liouville Problems
11.5 Bessel Series Expansion: Vibrating Drum
11.6 (If time permits: Series of Orthogonal Functions: Mean Convergence)

Catalog Description:
Discrete and continuous probability distributions, random variables, independence, expectation, variance.

Course Learning Outcomes:
By the end of this course, students should be able to:

- Understand the basic concepts in probability and statistics.
- Compute probabilities and statistics of discrete and continuous distributions.
- Comprehend the probabilistic methods needed to analyze and critically evaluate statistical models and arguments.
- Recognize the importance of statistical ideas.

Prerequisite:
C- or better in 2153, 2162.xx, 2173, 2177, 2182H, 4182H; or credit for 254.xx, 263.xx, 263.01H, or 264H.

Exclusions:
Not open to students with credit for any of 530, 5530H (531H), or Stat 4201 or 420.

Follow-up Courses:
Math 3589, Stat 4202.

Text:
Probability, by Pitman, published by Springer, ISBN: 9780387979748

Topics List:

I. Discrete probability.
1. First principles: outcome spaces, basic counting techniques, and partitions.
2. Venn diagrams and the inclusion-exclusion principle.
3. Conditional probability and independence; decision trees and Bayes' Theorem.
4. Discrete random variables; mass and generating functions; joint distributions.
5. Binomial, hypergeometric, geometric, negative binomial, and Poisson variables; applications and relationships.
6. Statistics on discrete variables.

II. Continuous probability
7. First principles: density functions, calculation of probabilities and statistics.
8. Moments and moment-generating functions.
9. Common distributions and their applications; exponential, gamma, uniform, normal.
10. The central limit theorem and normal approximation to the binomial distribution.
11. Relationships between the exponential, gamma, and Poisson distributions.
12. Hazard rates and survival functions.
13. Cumulative distribution functions, percentiles, and change of variables.
14. Joint distribution of continuous variables; independence and marginal distributions; density of a function of two variables

III. Statistics Material (using supplementary materials)
15. Chi-square distribution
16. t distribution
17. F distribution

Catalog Description:
Topics in calculus and analysis.

Prerequisites:
Either C- or better in 2153, 2162.xx, 2173, 2182H, or 4182H; or credit for 254, 263.xx, 263.01H, 264H, or equivalent;
-and- C- or better in Math 2568, 5520H, or equivalent.

Exclusions: Entry to this course is restricted to graduate students in Statistics or Biostatistics who have permission from the Departments of Statistics or Biostatistics.

Text:
Introduction to Real Analysis, by William F. Trench, Edition1.03, published by Library of Congress Cataloging-in-Publication Data, ISBN: 0-13-045786-8

Topics List:
1. Limits and continuity of functions.
2. Derivative, mean value theorem, optimization.
3. Sequences and series, uniform convergence, power series, Taylor's theorem.
4. Riemann integral, substitution, bounded variation, limit properties, Rieman-Stieltjes integral.
5. Multivariable functions, directional derivatives, chain rule, Taylor's theorem.
6. Inverse and implicit function theorems.

Catalog Description:
4547-4548 involves advanced calculus covering: sequences, limits, continuity, differentiation, Riemann integral, sequences and series of functions, Taylor series, and improper integrals.

Prerequisite:
C- or better in 3345; or credit for 345.

Text: Instructors will choose one of the following recommended texts:

Elementary Analysis, 2nd edition, by Kenneth A. Ross, published by Springer, ISBN: 978-1-4614-6271-2 (eBook), Available free through OSU libraries. Section 19 and Chapters 4-6.

Introduction to Real Analysis, 4th edition, by Bartle & Sherbert, published by Wiley, ISBN: 9780471433316, Section 5.4 and Chapters 6-10.

Topics List:

1. Sequences and their limits.
2. Bolzano-Weierstrass Theorem and Cauchy's criterion. Lim sup's and lim inf's.
3. Convergence and absolute convergence of series. Tests for convergence.
4. Continuity and limits of functions. Uniform continuity.

Catalog Description:
Continuation of Math 4547.

Prerequisite:
C- or better in 4547, or credit for 548.

Text: Instructors will choose one of the following recommended texts:

Elementary Analysis, 2nd edition, by Kenneth A. Ross, published by Springer, ISBN: 978-1-4614-6271-2 (eBook), Available free through OSU libraries. Section 19 and Chapters 4-6.

Introduction to Real Analysis, 4th edition, by Bartle & Sherbert, published by Wiley, ISBN: 9780471433316, Section 5.4 and Chapters 6-10.

Topics List:
1. Uniform continuity (Recap from 4547).
2. Derivatives, Mean Value Theorem, L'Hospital's rule.
3. Sequences and series of function, Pointwise and uniform convergence, Power series.
4. Riemann integral.
5. Exponential and logarithmic functions.

Catalog Description:
Vector operations; Jacobian and change of variables; div, grad and curl; Green's Stokes', and divergence theorems; applications.

Prerequisite:
C- or better in 2153, 2162.xx, 2173, or 2182H; or credit for 254.xx, 263.xx or 263.01H.

Exclusions:
Not open to students with credit for Math 4182H, 264H, 513 or 551.

Text:
Advanced Calculus, 5th edition, by Kaplan, published by Pearson, ISBN: 9780201799378

Topics List:
1. Vector operations, multiple integrals, line and surface integrals.
2. Vector operators: div, grad, and curl.
3. Jacobians and change of variables.
4. Green's Theorem, Stokes theorem.
5. Divergence Theorem.
6. Applications.

Catalog Description:
Introduction to analytic functions of a complex variable, integral theorems, power series, residues, conformal mapping.

Prerequisite:
C- or better in 2153, 2162.xx, 2173, 2182H, or 4182H; or credit for 254.xx, 263.xx, 263.01H, or 264H.

Exclusions:
Not open to students with credit for Math 5522H, 552 or 514.

Purpose:
This course provides a comprehensive introduction to complex analysis, emphasizing applications that are useful in science and engineering.

Text:
Complex Variables and Applications, 8th edition, by Brown & Churchill, published by McGraw-Hill, ISBN: 9780073383170

Topics List:

Complex numbers, polar form (Ch. 1)
Analyticity, Cauchy-Riemann equations (Ch. 2)
Elementary functions (Ch. 3)
Cauchy integral theorem and consequences (Ch. 4)

Midterm 1

Power series (Ch. 5)
Residues and poles (Ch. 6)
Applications of residues (Ch. 7)
Mapping by elementary functions (Ch. 8)
Conformal mappings (Ch. 9)

Midterm 2

Applications of conformal mappings (Ch. 10)
Schwarz-Christoffel transformation (Ch. 11)
Poisson integral, Dirichlet problem (Ch. 12)

Catalog Description:
Systems of linear, first-order differential equations; existence and uniqueness theorems; qualitative theory (phase plane analysis, linearization, stability, bifurcations, limit cycles, chaos); and physical applications.

Prerequisite:
C- or better in 2153, 2162.xx, 2173, 2182H, or 4182H; or credit for 254.xx, 263, 263H, or 264H.

Text:
Nonlinear Dynamics and Chaos, Steven H. Strogatz, published by Westview Press, ISBN 9780738204536

Topics List:

1. One-dimensional flows: geometric way of thinking; fixed points and stability; population growth and other applications.
2. Bifurcations in one-dimensional flows: saddle-node, transcritical and pitchfork bifurcations; imperfect bifurcations.
3. Theory: existence; uniqueness; continuous dependence.
4. Phase planes: phase portraits; vector fields; nullclines; fixed points; stability;
5. Linear systems: classification of linear systems; what do linear systems say about the nonlinear system?
6. Limit cycles; introduction; Poincare-Bendixson theorem; conservative systems.
7. Bifurcations of two-dimensional flows; Hopf bifurcation theorem.
8. XPPAUT: phase planes; bifurcations; applications.
9. Global bifurcations: homoclinic orbits; Poincare map; stability of periodic orbits.
10. Singular perturbations: Relaxation oscillators; averaging.
11. One-dimensional maps: Logistic map.
12. Smale horseshoe: symbolic dynamics.
13. Applications.

Catalog Description:
First and second-order PDE's; existence and uniqueness, initial and boundary value problems, Fourier series; Green's functions; wave, heat and Laplace equations; nonlinear PDE's; applications.

Prerequisite:
C- or better in 2255, 2415, 4556, or 5520H; or credit for 255, 415.xx, or 521H.

Exclusions:
Not open to students with credit for Math 4512 or 512.

Text:
Partial Differential Equations, an Introduction, 2nd edition, Walter A.Strauss, published by Wiley, ISBN: 0471548685.

Topics List:
1. Definition of a PDE, linearity; solution of first-order linear (transport) equation; modeling with PDEs.
2. Well-posed problems, initial- and boundary conditions; secondorder equations; classification into types; the wave equation.
3. Causality and energy; diffusion equation; diffusion on the whole line.
4. Solution of the wave and diffusion equations on a half-line; diffusion and waves with sources.
5. Separation of variables for the wave equation, Dirichlet, Neumann and Robin conditions.
6. Fourier series; sine and cosine series; orthogonality and general Fourier series; completeness and convergence.
7. Midterm. Gibbs phenomenon.
8. Laplace's equation; maximum principle; rectangular coordinates.
9. Poisson's formula; Laplace's equation in circular coordinates.
10. Green's identities; maximum principle; Dirichlet principle; Green's second identity.
11. Green's functions; symmetry; half-space and sphere.
12. Wave equation in two and three dimensions; energy; causality; Huyghens' principle.
13. Rays and characteristics; relativistic geometry; sources; the diffusion equation.
14. The Schrödinger equation; the hydrogen atom.

Catalog Description:
Matrix algebra, vector spaces and linear maps, bases and dimension, eigenvalues and eigenvectors, applications.

Prerequisite:
C- or better in 2153, 2162.xx, 1172, 2182H, or 4182H; or credit for 254, 263.xx, 263.01H or 264H.

Exclusions:
Restricted to graduate students in engineering. No open to students with credit for 2568 (568), 5101 (601), 5520H (520H) or 572.

Text:
Introduction to Linear Algebra, 5th edition, by L.W. Johnson, R.D. Riess, and J.T. Arnold, published by Pearson, ISBN: 9780321628217.

Topics List:

Part I

1.1 Introduction to Matrices and Systems of linear equations
1.2 Echelon Form and Gaussian-Jordan Elimination
1.3 Consistent Systems of linear Equations
1.5 Matrix Operations
1.6 Algebraic Properties of Matrix operations
1.7 Linear Independence and Nonsingular Matrices
1.9 Matrix Inverses and Their Properties

Midterm 1

Part II

2.1 Vectors in The Plane (Review only because it was done in 1152)
2.2 Vectors in Space (Review only because it was done in 1152)
2.3 The Dot Product and The Cross
3.1 Introduction
3.2 Vector Space Properties of R^n
3.3 Examples of Subspaces
3.4 Bases for Subspaces
3.5 Dimension
5.2 Vector Spaces
5.3 Subspaces
5.4 Linear Independence, Bases, and Coordinates

3.6 Orthogonal Bases for Subspaces
3.7 Linear Transformation from R^n to R^m

Midterm 2

Part III
4.1 The Eigenvalue Problem for 2x2 Matrices
4.2 Determinants and the Eigenvalue Problem
4.4 Eigenvalues and Characteristic Polynomial
4.5 Eigenvectors and Eigenspaces
4.6 Complex Eigenvalues and Eigenvectors
4.7 Similarity Transformations and Diagonalization

Final

THE OHIO STATE UNIVERSITY

Mathematics 4570
Applied Algebraic Topology
Spring
3 credits

Catalog Description:

This course will serve as an introduction to algebraic topology, with a view toward persistent homology of point clouds for applications to data analysis. Homology of simplicial complexes over a field with a focus on building up intuition about homology moving to a specialized notion of persistent homology of persistence modules. Real-world applications to data analysis will be provided.

Prerequisite:

C- or better in 2568 and 3345.

Text:

In-house course notes: Introduction to Applied Algebraic Topology by Tom Needham

https://drive.google.com/file/d/1SCrKHfZdDuMmSKlZ7xveQT8SqBHjFEkk/view

Topics List:

1. Review of Linear Algebra
2. Metric Topology
3. Homology of Simplicial Complexes
4. Point Clouds and Associated Spaces
5. Persistent Homology
6. Persistence Diagrams
7. Structures on the Space of Barcodes
8. Applications

THE OHIO STATE UNIVERSITY

Mathematics 4573
Elementary Number Theory
Spring (odd years)
3 credits

Catalog Description:
Prime numbers, modular arithmetic, Diophantine equations, combinatorial analysis; introduction to concepts of abstract algebra.

Purpose:
To introduce students to some topics in number theory at the upper undergraduate level and make connections to other areas of mathematics, such as combinatorics and abstract algebra.

Prerequisite:
C- or better in 3345 or 4181H; or credit for 345 or 264H.

Exclusions:
Not open to students with credit for Math 5576H, 576H or 573.

Follow-up Courses:
4580-4581; or for students with an honors background, 5590H-5591H

Text:
An Introduction to the Theory of Numbers, 5th edition, by Niven, Zuckerman & Montgomery, published by TBS, ISBN: 9780471625469

Topics List:
1. Prime numbers and factorization
2. Congruences and modular arithmetic; the Euler phi-function ø(n).
3. Fermat's "Little" Theorem. Primitive roots.
4. Quadratic Reciprocity
5. Numerical Functions of number theory; multiplicative functions and Moebius inversion
6. Diophantine equations.
7. Number theory from an algebraic viewpoint; groups, rings and fields.
8. Possible additional topics: continued fractions, Pell's equation, and elliptic curves.

Catalog Description:
Enumerative techniques, combinatorial identities, graph theory, algorithms, error correcting codes

Purpose for the Course:
Combinatorics and discrete mathematics are increasingly important, particularly for their applications in computer science. This course will give a brief overview of this subject.

Prerequisite:
C- or better in 2568 or 5520H; credit for 568, 571, or 520H.

Exclusions:
Not open to students with credit for Math 5529H.

Textbook:
Introductory Combinatorics, 5th Edition, by Richard A. Brualdi, Pearson, ISBN: 9780136020400

Topics List:
1. Counting principles: factorials, permutations and combinations, binomial coefficients, Stirling numbers, double counting.
2. Combinatorial identities: bijections, binomial theorem, generating functions.
3. Graph theory: bridges of Konigsberg, Eulerian circuits, trees, edge coloring, vertex coloring, planar graphs, Kempe's proof of the 5-color theorem
4. Error correcting codes: sphere packing bound, Hamming codes
5. (Optional.) Algorithms: Djkstra's algorithm for minimum spanning tree, depth first and breadth first algorithms for trees, greedy algorithm for graph coloring.

Catalog Description:
Homogeneous and non-homogeneous difference equations, Markov chains, graph theory, network flows, linear programming.

Prerequisite:
{C- or better in 2568 or 5520H; and C- or better in 4530, 5530H or Stat 420}; or {credit for 568, 571, or 520H; and credit for 530, 531H, or Stat 420}.

Exclusions: Not open to students with credit for 578.

Topics List:
1. Homogenous and non-homogeneous difference equations.
2. Application of Markov chains with absorbing and non-absorbing states, limiting behavior.
3. Hidden Markov models.
4. Graph theoretical algorithms, network flows, applications.
5. Linear/integer programming.

Comment:
This course requires the student to use a programming language chosen by the instructor to complete required coursework. Prior programming experience is not required.

Catalog Description:
4580-4581 includes group theory, ring theory, vector spaces over arbitrary fields, and field theory.

Prerequisite:
C- or better in 3345, or 3345H and C- or better in 2568 or 2568H or 5520H

Purpose:
Math 4580-4581 constitutes a two-semester sequence on abstract algebra, intended to introduce students the main concepts of this subject area. Focused on groups, rings and fields, this course gives the students a deep understanding of these three basic algebraic structures, and provides a good foundation for more specialized work. A significant goal of the course is to improve mathematical reasoning and proof writing.

Math 4580 presents special classes of groups, group actions on sets, vector spaces, and field theory that concludes with elements of Galois theory. The course places these topics in their historical context where possible.

Text:

Tom Judson, *Abstract Algebra: Theory and Applications*
https://aimath.org/textbooks/approved-textbooks/judson/

4580 Topics List (Chapters from Judson book):

1. **Preliminaries**
1.1. A Short Note on Proofs
1.2. Sets and Equivalence Relations

2. **Integers**
2.1. Mathematical Induction
2.2. The Division Algorithm

3. **Groups**
3.1. Integer Equivalence Classes and Symmetries
3.2. Definitions and Examples
3.3. Subgroups

4. **Cyclic Groups**
4.1. Cyclic Groups
4.2. Multiplicative Group of Complex Numbers

5. **Permutation Groups**
5.1 Definition and Examples
5.2 Dihedral Groups

6. **Cosets and Lagrange Theorem**
6.1. Cosets
6.2. Lagrange Theorem

9. **Isomorphisms**
9.1. Definition and Examples
9.2. Direct Products

10. **Normal Subgroups and Factor Groups**
10.1. Factor Groups and Normal Subgroups

11. **Homomorphisms**
11.1. Group Homomorphisms

16. **Rings**
16.1. Rings
16.2. Integral Domains and Fields
16.3. Ring Homomorphisms and Ideals
16.4. Maximal and Prime Ideals (optional)

17. **Polynomials**
17.1. Polynomial Rings
17.2. The division Algorithm (optional)
17.3. Irreducible Polynomials (optional)

Catalog Description:
4580-4581 includes group theory, ring theory, vector spaces over arbitrary fields, and field theory.

Prerequisite:
C- or better in Math 4580; or credit for 5590H or 581.

Purpose:
Math 4580-4581 constitutes a two-semester sequence on abstract algebra, intended to introduce students the main concepts of this subject area. Focused on groups, rings and fields, this course gives the students a deep understanding of these three basic algebraic structures, and provides a good foundation for more specialized work. A significant goal of the course is to improve mathematical reasoning and proof writing.

Math 4581 presents special classes of groups, group actions on sets, vector spaces, and field theory that concludes with elements of Galois theory. The course places these topics in their historical context where possible.

Text:
Tom Judson, *Abstract Algebra: Theory and Applications*
https://aimath.org/textbooks/approved-textbooks/judson/

4581 Topics List (Chapters from Judson book):

12. **Matrix Groups and Symmetry**
12.1. Matrix Groups
12.2 Symmetry

13. **The Structure of Groups**
13.1. The Structure of Finite Abelian Groups
13.2. Solvable Groups

14. **Group Actions on Sets**
14.1. Group Actions
14.2. The Class Equation
14.3. Burnside's Theorem

20. **Vector Spaces** (over arbitrary fields)
20.1. Definitions and Examples
20.2. Subspaces
20.3. Independence

17. **Polynomials** (a quick 1 day review of the results we will need for field theory)

21. **Fields**
21.1. Extensions
21.2. Splitting Fields
21.3. Geometric Constructions

22. **Finite Fields** (this chapter contains both characteristic and separability; cover them first)
22.1. Finite fields

23. **Galois Theory**
23.1. Field Automorphisms
23.2. Fundamental Theorem of Galois Theory
23.3. Applications (insolvability of the quintic by radicals)

Catalog Description:
Linear transformations and matrices, spectral theorem, ordinary differential equations, existence and uniqueness theorems, phase space, stability, oscillations.

Prerequisite:
C or better in 4182H or in both 2182H and 3345; or C or better in 264H or in both 263H and 345; or permission of department.

Text:
Linear Algebra: An Introductory Approach, revised 4th edition, by Curtis, published by Springer, ISBN: 9780387909929

Introduction to Ordinary Differential Equations, by Coddington, published by Dover, ISBN: 9780486659428

Topics List:
1. Vector spaces and linear transformations.
2. Systems of equations, determinants.
3. Spectral theorem.
4. Ordinary, linear and nonlinear differential equations.
5. Existence and uniqueness theorems.
6. Phase space, stability, and periodic points.

Catalog Description:
Theoretical treatment of complex analysis.

Prerequisite:
C or better in 5520H or permission of department.

Text:
Vary, for example:

- *An Introduction to Complex Function Theory,* by B.P. Palka
- *Elementary Theory of Analytic Functions of One or Several Complex Variables*, by H. Cartan
- *Complex Analysis*, 2nd edition, by Bak-Newman
- *Complex Analysis with Applications*, by Silverman

Topics List:

1. Complex numbers, Riemann's sphere. Complex functions, elementary functions, Möbius transformations.
2. Holomorphic functions, Cauchy-Riemann equations.
3. Line integrals. Cauchy's integration theorem and its consequences.
4. Harmonic functions.
5. Sequences and series of holomorphic functions. Power series, analytic functions.
6. Isolated singularities, meromorphic functions, the calculus of residues.
7. Conformal mappings, the Riemann mapping theorem.
8. Geometric principles.
9. Mittag-Leffler's and Weierstrass's expansions of meromorphic functions.
10. Analytic continuation, Riemann surfaces.
11. Applications to number theory, geometry, physics.

THE OHIO STATE UNIVERSITY

Mathematics 5529H
Honors Combinatorics
Autumn (even numbered years)
5 credits

Catalog Description:
Techniques of combinatorial mathematics; connections with geometry, algebra, analysis, and probability.

Prerequisite:
C or better in 4182H, or in both 2182H and 3345; or credit for 264H, or for both 263H and 345; or permission of department.

Text:
Vary, for example:

- *Discrete Mathematics*, by Lovasz, Pelican & Vestergombi, published by Springer, ISBN: 9780387955858
- *Proofs from the Book*, 4th edition, by Aigner, Ziegler & Hofmann, published by Springer, ISBN: 9783642008559
- *Combinatorics: Topics, Techniques, Algorithms*, by P. Cameron, published by Cambridge University Press, ISBN: 9780521338936

Topics List:

1. Counting principles.
2. Generating functions.
3. Combinatorial probability.
4. Finite fields and applications.
5. Theory of partitions.
6. Famous graphs.
7. Ramsey theory.
8. Permutation groups.

THE OHIO STATE UNIVERSITY

Mathematics 5530H
Honors Probability
Spring (odd numbered years)
5 credits

Catalog Description:
Theoretical treatment of probability, with applications within and outside mathematics.

Prerequisite:
C or better in 5529H, or permission of department.

Purpose of Course:
The acquaintance with rigorous probability theory, its history and its multiple connections, will better prepare honor students for graduate studies and will help them get involved in research at earlier stages of their careers.

Text:
Vary, for example:

- *Heads and Tails. An Introduction to Limit Theorems in Probability*, E. Lesigne, AMS, ISBN 0821837141
- *Elementary Probability Theory with Stochastic Processes*, Kai Lai Chung
- *Elementary Probability Theory*, Kai Lai Chung and Farid AitSahlia,, 4th Edition, Springer, 2003

Topics List:

1. Historical origins of probability.
2. Diverse ways of sampling, allocation, models.
3. Random variables, expectation, moments.
4. Important distributions.
5. Limit theorems: law of large numbers, central limit theorem.
6. Random walks and Markov chains.
7. Statistical independence in analysis and number theory.

Mathematics 5540H
Honors Differential Geometry
Spring (even numbered years)
5 credits

Catalog Description:
Geometry of curves and surfaces in 3-dimensional space, curvature, geodesics, Gauss-Bonnet Theorem, Riemannian metrics.

Prerequisite:
C or better in 5520H, or in both 2182H and 2568; or credit for 520H, or in both 263.01H and 568; or permission of department.

Text:
Text vary, for example:

- *Differential Geometry of Curves and Surfaces*, DoCarmo
- *Elements of Differential Geometry*, R. Milman and G. Rarker

Topics List:

1. Geometry of curves; Frenet-Serret equations.
2. Curvature of surfaces, First Fundamental Form, Gauss's Theorema Egregium.
3. Geodesics, exponential map.
4. Isometries, conformal mappings; mapmaking.
5. Gauss-Bonnet Theorem.
6. Riemannian metrics, non-Euclidean geometry.

THE OHIO STATE UNIVERSITY

Mathematics 5576H
Honors Number Theory
Autumn (odd numbered years)
5 credits

Catalog Description:
Elementary analytic and algebraic number theory, tracing its unifying role in the development of mathematics through history.

Prerequisite:
C or better in 4182H, or in both 2182H and 3345; or credit for 264H, or for both 263H and 345; or permission of department.

Purpose of Course:
The intention of this course is to present number theory, the "Queen of Mathematics" through its historical development. Being one of the oldest mathematical disciplines, number theory, in the course of its history, both benefited from and contributed to such major mathematical areas as geometry, algebra and analysis. These courses will be especially beneficial for honor students planning to pursue careers in mathematics, physics, computer science and education, but may be of interest to engineering students as well.

Text:
Vary, for example:

- *An Introduction to the Theory of Numbers*, 6th edition, by Hardy, Wright, Heath & Brown, published by Oxford, ISBN: 9780199219865.
- *An Introduction to the Theory of Numbers*, I. Niven, H.S. Zukkerman, H.L. Montgomery
- *Number Theory: An Introduction to Mathematics, Parts A and B*, by William A. Coppel, Springer-Velag.

Topics List:

1. Review of Egyptian and Mesopotamian Mathematics. Greek tradition. Three classical Greek problems (cube doubling, angle trisection, circle quadrature).
2. Famous irrationalities.
3. Continued fractions and applications thereof (quadratic surds, Pell's equation, Diophantine approximations, etc.)
4. More on diophantine approximation. Algebraic numbers. Liouville numbers. A glimpse into the Thue-Siegel-Roth Theorem.
5. Uniform distribution modulo one. Weyl criterion. Some important sequences. Pisot-Vijayaraghavan numbers. Formulation and discussion of Margulis' solution of Oppenheimer's conjecture.
6. Normal numbers. Champernoun's example. Almost every number is normal. Levy-Khinchine Theorem on normality of continued fractions.
7. Infinitude of primes. Euler's identity. Chebyshev's Theorem. Bertrand's Postulate. Dirichlet's Theorem on primes in progressions. Average rate of growth of classical number-theoretical functions.
8. Finite fields. Wedderburn's Theorem. Applications: Latin Squares and Cryptography.
9. Quadratic reciprocity.

10. Pythagorean triangles. Representation of integers as sums of squares. Quaternions, Cayley's octavas. Hurwitz' Theorem. Minkowski's geometry of numbers.
11. *p*-adic numbers, their construction and axiomatic characterization (Ostrowski's Theorem). Minkowski-Hasse principle.
12. Fermat's last theorem. Some easy cases. A glimpse into modern developments (elliptic curves, Mordell-Weil Theorem, etc.).

Catalog Description:
5590H and 5591H includes elementary number theory, group theory, ring theory, abstract linear algebra, field theory, and Galois theory.

Prerequisite:
5590H: C or better in 5520H or in 520H, or permission of department.
5591H: C or better in 5590H or permission of department.

Text:
Vary, for example:

- *Abstract Algebra*, 3rd edition, by Dummit & Foote, published by Wiley, ISBN: 9780471433349
- *Algebra*, by M. Artin
- *Topics in Algebra*, by I. Herstein

Topics List:

5590H:

1. Integers, unique factorization; congruences, Euler function.
2. Groups, subgroups, homomorphisms and isomorphisms, normal subgroups, quotient groups, permutation groups, cyclic groups, Cauchy Theorems, Sylow's Theorems; direct products, fundamental theorem for finite Abelian group; G-sets.
3. Rings, subrings, ideals, morphisms, polynomial rings, prime and maximal ideals.
4. Commutative rings, factorization theory, Euclidean rings, principal ideal rings, unique factorization domains, Gauss' lemma; illustrations in the integers of quadratic number fields.
5. Modules over commutative rings, submodules, quotients and direct sums; fundamental theorem for modules over principal ideal domains.

5591H:

1. Vector spaces (as a special case of modules); linear maps and matrices, canonical forms, dual spaces.
2. The theory of determinants.
3. Bilinear and quadratic forms; inner product and unitary spaces; principal axis theorem.
4. Fields, algebraic and transcendental (extensions), existence of closure (over countable fields), tests for polynomial irreducibility; normality, separability, field automorphisms.
5. Galois theory, the subgroup-subfield correspondence theorem, group theory interrelations; extensions of finite fields, cyclotomic extensions.
6. Solvable groups and solvability by radicals.

Catalog Description:
5630-5631 introduces students to the mathematical theory of contingencies. Includes material from examinations by the Society of Actuaries and the Casualty Actuarial Society.

Prerequisite:
C- or better in 3618 **and** C- or better in 4530, 5530H, or Stat 4201; or credit for 530, 531H, or Stat 420; or permission of department.

Exclusions:
Open only to actuarial science majors.

Text:
Actuarial Mathematics for Life Contingent Risks, by Dickson, Hardy & Waters, published by Cambridge, ISBN: 9780521118255

Topics List:
1. Survival distributions.
2. Individual risk models.
3. Life tables.
4. Topics from life insurance.
5. Life annuities.
6. Benefit premiums.

Catalog Description:
5630-5631 introduces students to the mathematical theory of contingencies. Includes material from examinations by the Society of Actuaries and the Casualty Actuarial Society.

Prerequisite:
C- or better in Math 5630, or credit for 630.

Exclusions:
Open only to actuarial science majors, and to MMS students specializing in Financial Math.

Text:
Actuarial Mathematics for Life Contingent Risks, by Dickson, Hardy & Waters, published by Cambridge, ISBN: 9780521118255.

Topics List:
1. Benefit reserve.
2. Multiple life functions.
3. Multiple decrement models.
4. Random and deterministic survivorship group.
5. Valuation of pension plans.
6. Applications.

Catalog Description:
Introduction to the evaluation of options, futures, and other derivatives, interest models and risk management techniques. Includes material from examinations by the Society of Actuaries and the Casualty Actuarial Society.

Prerequisite:
{C- or better in 3618, or credit for 618, or permission of department} –and– {C- or better in 4530 or Stat 4201 or credit for 530 or Stat 420}.

Exclusions:
Restricted to actuarial science majors, math majors, and students with graduate standing.

Text:
Derivatives Markets, 2nd edition, by McDonald, published by Addison-Wesley, ISBN: 9780321280305

Topics List:
1. Option relationships.
2. Binomial option pricing.
3. Black-Scholes formula.
4. Market making and delta hedging.
5. Exotic options.
6. Brownian motions and Ito's Lemma.
7. Interest rate models.

Catalog Description:
5633-5634 introduces students to the construction and evaluation of actuarial models, with topics covered by examinations of the Society of Actuaries and the Casualty Actuarial Society.

Prerequisite:
{C- or better in 4530, 5530H, Stat 4201, or credit for 530, 531H, or Stat 420}; and {C- or better in Stat 4202 or credit for Stat 421}.

Exclusions:
Open only to actuarial science majors and to MMS students specializing in Financial Math.

Text:
Loss Models: From Data to Decisions, 4th edition, by Klugman, Panjer and Willmot, published by Wiley, ISBN: 9781118315323.

Topics List:
1. Measures of risk.
2. Characteristics of actuarial models.
3. Severity models.
4. Frequency models.
5. Aggregate loss models.

Catalog Description:
5633-5634 introduces students to the construction and evaluation of actuarial models, with topics covered by examinations of the Society of Actuaries and the Casualty Actuarial Society.

Prerequisite:
C- or better in 5633.

Exclusions:
Open only to actuarial science majors and to MMS students specializing in Financial Math.

Topics List:
1. Estimation of data.
2. Parameter estimation.
3. Model selection.
4. Simulation.
5. Credibility.

Catalog Description:
Special relativity as moving frames; tensors, exterior algebra and exterior calculus; differentiable manifolds and space time structures; parallel transport, torsion and curvatures, metric compatibility; structure equations of differential geometry.

Prerequisite:
Multivariable differential calculus and linear algebra (e.g. Math 2568 and/or 5101). A physics course (e.g. Physics 133 or higher). No prior knowledge of tensor calculus is assumed. However, we do assume a mature attitude towards mathematics and physics.

Purpose:
Develop from the bottom up the fundamental mathematical concepts and methods responsible for the successes in 20th century physics, mathematics, and theoretical engineering. Thus Math 5756 concretizes these developments in terms of:

a) Special Relativity as the cognitive bridge to 20th century geometry
b) Multilinear algebra as a source of geometrical structures,
c) Linear algebra's marriage to multi-variable calculus
d) differential geometry as a three level hierarchy characterized by its
    - Differential structure
    - Parallel transport structure (a.k.a. covariant derivative)
    - Metric structure
e) The exterior calculus
f) Cartan's two structural equations for the various flavors of differential geometry, and their application to
g) The Cartan-Misner calculus

Text:
a) *Gravitation* by C. W. Misner, K. S. Thorne, and J. A. Wheeler.
b) Selections from *Mathematical Methods of Classical Mechanics* by V.I. Arnold.
c) Selections from *Lecture Notes on Elementary Topology and Geometry* by I. M. Singer.
d) Selections from *Spacetime Physics*, 2nd edition, by E. Taylor and J.A. Wheeler

Topics List:

Math 5756 (Autumn):

A rapid course in special relativity: spacetime geometry, event horizons and accelerated frames;

- tensors, metric geometry vs symplectic geometry;
- exterior calculus, Maxwell field equations;
- manifolds, Lie derivatives, and Hamiltonian dynamics in phase space;
- parallel transport, torsion, tensor calculus;
- curvature and Jacobi's equation of geodesic deviation;
- Cartan's two structural equations, metric induced properties, and Cartan-Misner curvature calculus.

Math 5757 (Spring):

- Geodesics: Hamilton-Jacobi theory, the principle of constructive interference;
- stress-energy tensor: hydrodynamics in curved spacetime and Einstein field equations;
- The conservation laws and the Bianch identities mathematized in terms of the "Boundary of a Boundary is zero (@ @ - = 0)" Principle.
- Solutions to the Einstein's field equations: stars, black holes, gravitational collapse, geometry and dynamics of the universe;
- vector harmonics, tensor harmonics, acoustic and gravitational waves in violent relativistic backgrounds.