

Mathematics (Math)

<http://www.arts-sciences.und.edu/math>

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The functions of the Mathematics Department within the total framework of the University are varied. Besides the training of undergraduate and graduate majors in the field of Mathematics, the Department offers courses designed to meet the needs of students in business; engineering; physical, social, and biological sciences; and elementary and secondary education.

The student considering mathematics as a career should realize that emphasis in mathematics courses will change as he/she progresses through college and graduate school. The early emphasis on solving problems is later subordinated to the more important tasks of formulating problems in mathematical language and of dealing effectively with mathematical structures and abstract ideas.

It should be stressed that an effective mathematician in any type of employment should be a well-educated person. He/she should have not only the technical background of calculus and differential equations taken by most scientists and engineers, and the more advanced mathematical training required for a major in mathematics, but should also have taken a selection of courses from other disciplines. A student who plans to continue beyond the bachelor's degree in mathematics should also acquire a reading knowledge of at least one and preferably two of the foreign languages in which much of the current literature in mathematics is written, namely, German, Russian, and French. All students should, of course, acquire fluency in the written and oral expression of ideas in English.

The main fields of opportunity in mathematics today are teaching, statistics, data analysis, consulting, information theory, and actuarial mathematics.

Students may pursue the B.S. degree with a major in mathematics through the College of Arts and Sciences. Secondary teacher licensure is possible when appropriate requirements are met.

Elective courses to be taken toward the bachelor's degree are decided in consultation with an adviser from the Mathematics Department, and vary according to the needs of the student, consistent with the particular objective of the general education and mathematical education of the student.

Placement in Mathematics. Appropriate initial enrollment in mathematics courses at UND is determined by a combination of entrance and placement tests or the acceptance of credits for transfer, Advanced Placement (AP) and College Level Examination Program (CLEP). Students enrolling without such previous credit are directed to entry level mathematics courses, courses numbered 092 through 165 and 277 depending on their scores on the ACT Mathematics test and/or a combination of scores on tests from the Placement Testing Protocol.

Anyone without the required prerequisites enrolling in a mathematics course may be dropped from the class by the instructor.

College of Arts and Sciences

B.S. with Major in Mathematics

All students are urged to take courses in disciplines which make use of mathematics such as Physics, Chemistry, Engineering, Computer Science and Biology. Students considering graduate school are strongly urged to take MATH 441 Abstract Algebra, and a full year of and MATH 432 Introduction to Analysis II.

Required 125 credits (36 of which must be numbered 300 or above, and 60 of which must be from a 4-year institution) including:

I. Essential Studies Requirements (see University ES listing).

II. Non-Mathematics Requirements:

Three hours of Computer Science as approved by the Mathematics Department (see <http://www.und.edu/dept/math/majinfo.html>).

III. The Following Curriculum of 38 Major Hours:

A. Mathematics Core

MATH 165 & MATH 166 & MATH 265	Calculus I and Calculus II and Calculus III	12
MATH 207	Introduction to Linear Algebra	2
MATH 266	Elementary Differential Equations	3
MATH 488	Senior Capstone	3
Total Credits		20

B. Breadth Requirement

One course from each of the following areas (9)

- Theoretical Mathematics:* Courses where the emphasis is on development of theory from basic principles:

MATH 330	Set Theory and Logic	3
MATH 403	Theory of Probability (if not used for category 3)	3
MATH 405	Selected Topics in Mathematics (pre-approval of topic required)	1-3
MATH 409	Geometry	3
MATH 431	Introduction to Analysis I	3
MATH 435	Theory of Numbers	3
MATH 441	Abstract Algebra	3
MATH 442	Linear Algebra	3
- Applications of Mathematics:* Courses where the emphasis is on applications of mathematics:

MATH 352	Introduction to Partial Differential Equations	3
MATH 412	Differential Equations	3
MATH 415	Topics in Applied Mathematics (pre-approval of topic required)	1-3
MATH 425	Cryptological Mathematics	3
MATH 460	Mathematical Modeling	3
MATH 461	Numerical Analysis	3
MATH 471	Introduction to Complex Variables	3
- Probability and Statistics:*

MATH 321	Applied Statistical Methods	3
MATH 403	Theory of Probability (if not used for category 1)	3
MATH 416	Topics in Statistics	1-3
MATH 421	Statistical Theory I	3

C. Depth Requirement

Courses used to satisfy C may also be used to satisfy a portion of B.

Select one of the following:		6
MATH 352 & MATH 412	Introduction to Partial Differential Equations and Differential Equations	
MATH 403 & MATH 416	Theory of Probability and Topics in Statistics (pre-approval of topic in 416 required)	
MATH 408 & MATH 425	Combinatorics and Cryptological Mathematics	
MATH 421 & MATH 422	Statistical Theory I and Statistical Theory II	
MATH 431 & MATH 432	Introduction to Analysis I and Introduction to Analysis II	
MATH 435 & MATH 441	Theory of Numbers and Abstract Algebra	
MATH 441 & MATH 442	Abstract Algebra and Linear Algebra	

D. Electives

Math courses numbered 208 and above, excluding MATH 277 Mathematics for Elementary School Teachers, MATH 377 Geometry Elementary Teachers, MATH 400 Methods for Teaching Middle and Secondary Mathematics; Pedagogical Content Knowledge, MATH 477 Topics in Elementary School Mathematics (3-9 to bring the total number of credits to 38)

Teacher Licensure

Through a partnership with the College of Education and Human Development and the Department of Teaching and Learning, students may seek secondary licensure in Mathematics. The following program of study must be completed:

I. Mathematics program of study

1. The Essential Studies, Non-Mathematics, and Mathematics Core requirements as described above.
2. The following courses to satisfy the breadth requirement:
 - a. *Theoretical Mathematics*: MATH 330 Set Theory and Logic
 - b. *Probability and Statistics*: MATH 321 Applied Statistical Methods
 - c. *Teaching Content Requirements*: MATH 208 Discrete Mathematics, MATH 308 History of Mathematics, MATH 409 Geometry
3. The following sequence:
MATH 435 Theory of Numbers & MATH 441 Abstract Algebra

II. Admission to the Secondary Program, normally while taking T&L 250 Introduction to Education. (See College of Education and Human Development (<http://und-public.courseleaf.com/educationandhumandevlopment>) for admission and licensing requirements.)

III. The program in Secondary Education (see Teaching & Learning (<http://und-public.courseleaf.com/undergraduateacademicinformation/departementalcoursesprograms/teachingandlearning>)):

Mathematics majors seeking secondary licensure must have an advisor in both the Mathematics Department and the Department of Teaching and Learning.

Minor in Mathematics

Required 20 credits as follows:

MATH 165	Calculus I	8
& MATH 166	and Calculus II	
Math electives numbered 207 or higher *		12
Total Credits		20

* not including MATH 217 Introduction to Cultural Mathematics, , MATH 277 Mathematics for Elementary School Teachers, MATH 377 Geometry Elementary Teachers, MATH 400 Methods for Teaching Middle and Secondary Mathematics; Pedagogical Content Knowledge and MATH 477 Topics in Elementary School Mathematics.

MATH 405 Selected Topics in Mathematics, MATH 415 Topics in Applied Mathematics, MATH 416 Topics in Statistics, MATH 494 Reading Course in Mathematics, and MATH 495 Readings in Mathematics may be used only with prior approval from the Mathematics Department.

Minor in Mathematics for Elementary Education

Required 20 credits of Mathematics, including:

MATH 115	Introduction to Mathematical Thought	3
MATH 277	Mathematics for Elementary School Teachers	3
MATH 377	Geometry Elementary Teachers	3
MATH 477	Topics in Elementary School Mathematics	3
Select at least one of the following:		3-4
MATH 146	Applied Calculus I	
MATH 165	Calculus I	
MATH 166	Calculus II	
MATH 208	Discrete Mathematics	

All electives may be selected from Mathematics courses above Math 093.

Minor in Statistics (Plan A)

Prerequisites

MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265	Calculus III	4

Required courses

MATH 421	Statistical Theory I	3
MATH 422	Statistical Theory II	3
Select one of the following:		3
BIOL 470	Biometry	
EFR 513	Large Dataset Analysis	
EFR 514	Discourse Analysis	
EFR 516	Statistics II	
CHE 515	Design of Engineering Experiments	
ECON 410	Empirical Methods in Economics I	
EE 411	Communications Engineering	
MATH 321	Applied Statistical Methods	
MATH 403	Theory of Probability	
MATH 415	Topics in Applied Mathematics	
MATH 416	Topics in Statistics	
PSYC 541	Advanced Univariate Statistics	
PSYC 542	Multivariate Statistics for Psychology	
PSYC 543	Experimental Design	
SOC 521	Advanced Statistical Methods	

Total Credits 21

Minor in Statistics (Plan B)

Prerequisites

MATH 146	Applied Calculus I	3
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Required courses

BIOL 470	Biometry	4
EFR 513	Large Dataset Analysis	3
EFR 514	Discourse Analysis	3
EFR 516	Statistics II	3
CHE 515	Design of Engineering Experiments	3
Select one of the following:		3

ECON 210	Introduction to Business and Economic Statistics	
PSYC 241	Introduction to Statistics	
SOC 326	Sociological Statistics	
ECON 410	Empirical Methods in Economics I	
EE 411	Communications Engineering	
MATH 321	Applied Statistical Methods	
MATH 403	Theory of Probability	
MATH 415	Topics in Applied Mathematics	
MATH 416	Topics in Statistics	
MATH 421	Statistical Theory I	
MATH 422	Statistical Theory II	
PSYC 541	Advanced Univariate Statistics	
PSYC 542	Multivariate Statistics for Psychology	
PSYC 543	Experimental Design	
SOC 521	Advanced Statistical Methods	

Total Credits 22

NOTE: PTP* indicates an appropriate score in the Placement Testing Program (PTP) is required.

Courses

MATH 92. Algebra Prep II. 2 Credits.

This course continues the development of the fundamental skills required for the successful completion of studies in college level mathematics courses. Topics include the solutions of linear equations and inequalities, formula manipulation, Cartesian geometry and the graphing of linear equations and inequalities, systems of equations, and an introduction to functions. Study skills will be incorporated throughout the course. Credit earned does not count toward any degree, nor does it transfer. Prerequisite: Placement by appropriate ACT Math sub-score or Math Placement Exam score. F,S,SS.

MATH 93. Algebra Prep III. 2 Credits.

This course continues the development of the fundamental skills required for the successful completion of studies in college level mathematics courses. Topics include exponents and radicals, algebraic manipulation involving polynomial and rational forms, and unit analysis. Study skills will be incorporated throughout the course. Credit earned does not count towards any degree, nor does it transfer. Prerequisite: MATH 92 or Placement by appropriate ACT Math sub-score or Math Placement Exam score. F,S,SS.

MATH 103. College Algebra. 3 Credits.

Polynomial and rational functions, inverse functions, exponential and logarithmic functions, simple conics, systems of equations, determinants, arithmetic and geometric sequences, the Binomial Theorem. Sections meeting 5 days per week are offered for students determined eligible by the Math Department. Prerequisite: Appropriate score in the Placement Testing Program or MATH 93. F,S,SS.

MATH 105. Trigonometry. 2 Credits.

Angles, trigonometric functions and their inverses, solving triangles, trigonometric identities. Prerequisite: One year of high school geometry and either an appropriate score in the Placement Testing Program or MATH 93. S.

MATH 107. Precalculus. 4 Credits.

Equations and inequalities; polynomial rational, exponential, logarithmic and trigonometric functions; inverse trigonometric functions; algebraic and trigonometric methods commonly needed in calculus. Prerequisite: MATH 93 or an appropriate score in the Placement Testing Program. F,S,SS.

MATH 112. Transition to Calculus. 1 Credit.

This course is designed for students intending to take MATH 165, Calculus I who have mastered most of, but not all, the material covered in MATH 107, Pre-Calculus. Emphasis is therefore on topics such as inverse functions, partial fraction expansion, trigonometric identities, and applications of trigonometry, which are deemed most difficult for pre-calculus students. Prerequisite: MATH 107 or MATH 146 or an appropriate score in the Placement Testing Program. S/U grading. F.

MATH 115. Introduction to Mathematical Thought. 3 Credits.

The course will focus on analysis and interpretation of common types of mathematical arguments as well as having students construct their own arguments. A combination of topics will be included, such as: elementary combinatorics, probability, statistics, set theory, number theory, geometry and topology, mathematical logic, the mathematics of voting, etc. F.

MATH 146. Applied Calculus I. 3 Credits.

A nonrigorous introduction to differential and integral calculus. Topics include limits, continuity, differentiation and integration techniques, and applications. Prerequisites: MATH 103 or an appropriate score in the Placement Testing Program. F,S,SS.

MATH 165. Calculus I. 4 Credits.

Limits, continuity, differentiation, Mean Value Theorem, integration, Fundamental Theorem of Calculus. Prerequisite: an appropriate score in the Placement Testing Program or MATH 112 or completion of MATH 107 with a grade of C or better. F,S,SS.

MATH 166. Calculus II. 4 Credits.

Techniques and applications of integration, exponential and logarithmic functions, parametric equations, infinite sequences and series. Prerequisites: Completion of MATH 165 with a grade of C or better; or permission of the Mathematics Department. F,S,SS.

MATH 207. Introduction to Linear Algebra. 2 Credits.

A computational treatment of systems of linear equations, finite dimensional vector spaces, linear transformations, determinants, matrices, eigenvalues, eigenvectors, and diagonalizability. Prerequisite: MATH 165. F,S.

MATH 208. Discrete Mathematics. 3 Credits.

Introduction to Set Theory, Functions and Relations, Permutations and Combinations, Logic, Boolean Algebra, Induction, Difference Equations. Other topics from Graphs, Finite Automata and Formal Languages. Prerequisite: an appropriate score in the Placement Testing Program or MATH 103 or MATH 107. F,S,SS.

MATH 217. Introduction to Cultural Mathematics. 3 Credits.

This course covers mathematical concepts within the context of cultures. Mathematical ideas are investigated in topics such as number systems, calendars, art, kinship relations, divination, and games. Examples are taken from cultures in many parts of the world. The main emphasis in the course is on learning how cultural activities can be considered mathematical and often include non-trivial mathematical ideas. One or more case studies of particular cultures will also be included. The case studies will consist of investigations into several cultural aspects that have mathematical connections. Prerequisite: A grade of C or better in MATH 103. S, odd years.

MATH 265. Calculus III. 4 Credits.

Multivariate and vector calculus including partial derivatives, multiple integration, line and surface integrals, Green's Theorem, Stokes' Theorem, the Divergence Theorem. Prerequisite: MATH 166. F,S,SS.

MATH 266. Elementary Differential Equations. 3 Credits.

Solution of elementary differential equations by elementary techniques. Laplace transforms, introduction to matrix theory and systems of differential equations. Prerequisites: MATH 265 and proficiency in a programming language. F,S,SS.

MATH 277. Mathematics for Elementary School Teachers. 3 Credits.

Development of the number systems used in elementary schools. Includes some methods and work with laboratory materials. For elementary education majors only. Prerequisites: Admission to Teacher Education and either an appropriate score in the Placement Testing Program or MATH 103. F,S.

MATH 308. History of Mathematics. 3 Credits.

This is a course on the conceptual and chronological history of mathematics. The course involves the interpretation and analysis of how and why mathematical ideas have developed over time, including political and cultural considerations. Topics include: numbers and counting systems, non-Western developments, mathematics of Egypt, Babylonia and Greece, early European developments, the Renaissance, the Scientific Revolution and the development of calculus, women in mathematics, twentieth century mathematics. Prerequisite: MATH 166 or equivalent, or consent of instructor. S.

MATH 315. Topics in Computational Mathematics. 1-3 Credits.

An introduction to mathematical methods useful in the computational analysis of problems in applied mathematics. Topics may include numerical methods, numerical simulation, symbolic computation, and theory of computation. May be repeated for credit with consent of instructor up to six credits. Prerequisites: MATH 266 and proficiency in a programming language, or consent of instructor. Repeatable to 6 credits. On demand.

MATH 321. Applied Statistical Methods. 3 Credits.

Introductory statistics for students with a background in single-variable calculus. Topics include descriptive statistics, continuous and discrete probability density functions, sampling distributions, point and interval estimation, and tests of hypotheses. Prerequisite: MATH 166. F,S.

MATH 330. Set Theory and Logic. 3 Credits.

Axioms and operations on sets, mathematical logic, relations and functions, development of the natural and real number systems, including field axioms and the completeness axiom for the real numbers. Prerequisite: MATH 166 or consent of instructor. F,S.

MATH 352. Introduction to Partial Differential Equations. 3 Credits.

Partial differential equations, Fourier series, special functions, series solutions to ordinary differential equations. Prerequisite: MATH 266. S.

MATH 377. Geometry Elementary Teachers. 1-3 Credits.

Experimental and inductive discovery in building geometric concepts at the elementary school level. Prerequisite: For elementary education majors only. On demand.

MATH 397. Cooperative Education. 1-8 Credits.

A practical work experience with an employer closely associated with the student's academic area. 1-8 credits repeatable to 18. Arranged by mutual agreement among student, department, and employer. A maximum of 6 cooperative education credits may be applied against requirements for a Math major. Prerequisites: 15 completed credits in math including MATH 165, MATH 166, and MATH 265, in addition to standard co-op requirements (see department for approval). Repeatable to 18 credits. S/U grading. F,S,SS.

MATH 399. Methods for Secondary Teachers: Mathematical Content Knowledge. 3 Credits.

National and State Standards for teaching and learning secondary mathematics. Secondary mathematics content from an advanced perspective. Technology for learning mathematics. Current issues and recent developments in mathematics curriculum and in effective instructional practices. Prerequisite: 9 hours of upper division mathematics, excluding MATH 377 and MATH 477. S.

MATH 400. Methods for Teaching Middle and Secondary Mathematics; Pedagogical Content Knowledge. 3 Credits.

National and State Standards for teaching and learning secondary mathematics. Teaching methods, strategies and materials for effective standards-based teaching and learning of mathematics in middle and secondary schools. Preparation/evaluation of assessments, unit plans, and materials of instruction. Appropriate use of technology for mathematics instruction. Prerequisites: T&L 250 and T&L 345. Corequisite: T&L 486. F.

MATH 403. Theory of Probability. 3 Credits.

Sets, sample spaces, discrete probability, distribution functions, density functions, characteristic functions, study of normal, Poisson, binomial and other distributions with applications. Prerequisite: MATH 265. S, odd years.

MATH 405. Selected Topics in Mathematics. 1-3 Credits.

May be repeated to maximum of six credits. Prerequisite: Permission of the Mathematics Department. Repeatable to 6 credits. On demand.

MATH 408. Combinatorics. 3 Credits.

Introduction to the techniques and reasoning needed in combinatorial problem-solving. The course may include topics related to combinatorics, such as graph theory. Prerequisites: MATH 166 and MATH 208. S.

MATH 409. Geometry. 3 Credits.

Metric and synthetic approach to Euclidean geometry. The usual topics in elementary geometry treated in a mathematically logical way. Topics include congruence, inequalities, parallelism, similarity, area, solid geometry and the circle. Prerequisite: MATH 208 or MATH 330. F.

MATH 412. Differential Equations. 3 Credits.

Basic types of ordinary differential equations. Existence and uniqueness of solutions. Prerequisite: MATH 266. F, odd years.

MATH 415. Topics in Applied Mathematics. 1-3 Credits.

An introduction to selected areas in applied mathematics chosen from a variety of topics including: Applied algebra, difference equations, linear programming, modeling and simulation, operations research, optimization, partial differential equations and computers in mathematics. Topics to be considered will be illustrated with examples and practical applications. May be repeated for credit with consent of instructor up to a maximum of six credits. Prerequisites: MATH 265 and consent of instructor. Repeatable to 6 credits. On demand.

MATH 416. Topics in Statistics. 1-3 Credits.

An introduction to a variety of topics in statistics including: Linear models in categorical analysis, Bayesian methods, decision theory, ridge regression, Non parametric techniques, stochastic games and models. The number of topics to be considered during a semester will be limited to permit greater depth of coverage and sufficient practical illustrations. May be repeated for credit with consent of instructor up to six credits. Prerequisites: MATH 265 and MATH 321 or consent of instructor. Repeatable to 6 credits. On demand.

MATH 421. Statistical Theory I. 3 Credits.

Discrete and continuous random variables, expectation, moments, moment generating functions, properties of special distributions, introduction to hypothesis testing, sampling distributions, Central Limit Theorem, curve of regression, correlation, empirical regression by least squares, maximum likelihood estimation, Neyman-Pearson lemma, likelihood ratio test, power function, chi-square tests, change of variable, "t" and "F" tests, one and two-way ANOVA, nonparametric methods. Prerequisite: MATH 265. F.

MATH 422. Statistical Theory II. 3 Credits.

Discrete and continuous random variables, expectation, moments, moment generating functions, properties of special distributions, introduction to hypothesis testing, sampling distributions, Central Limit Theorem, curve of regression, correlation, empirical regression by least squares, maximum likelihood estimation, Neyman-Pearson lemma, likelihood ratio test, power function, chi-square tests, change of variable, "t" and "F" tests, one and two-way ANOVA, nonparametric methods. Prerequisite: MATH 421. S.

MATH 425. Cryptological Mathematics. 3 Credits.

This course develops the math behind elementary symmetric-key cryptoschemes and a variety of public-key schemes. Modern block ciphers may be discussed. Prerequisite: MATH 208. F, odd years.

MATH 431. Introduction to Analysis I. 3 Credits.

Development of the real number system, functions, sequences, limits, continuity, and differentiation. Prerequisite: MATH 330 or consent of instructor. F.

MATH 432. Introduction to Analysis II. 3 Credits.

A continuation of MATH 431, topics in the second semester include integration, partial differentiation, infinite series, power series and vector analysis. Prerequisite: MATH 431. S.

MATH 435. Theory of Numbers. 3 Credits.

Basic properties of numbers, including divisibility, primes, congruences, Diophantine equations and residue theory. Prerequisite: MATH 208 or 330. S.

MATH 441. Abstract Algebra. 3 Credits.

Rings, integral domains, fields, elements of group theory. Prerequisite: MATH 330 or consent of instructor. F.

MATH 442. Linear Algebra. 3 Credits.

A theoretical treatment of systems of linear equations, matrices, vector spaces, linear transformations and elementary canonical forms. Prerequisites: MATH 207 and MATH 330 or consent of instructor. S.

MATH 460. Mathematical Modeling. 3 Credits.

The primary goal of the course is to present the mathematical analysis provided in scientific modeling. Topics may include population modeling, mechanical vibrations, traffic flow, epidemic modeling, queues and decay processes. Prerequisites: MATH 266 and MATH 207 or consent of instructor. F, even years.

MATH 461. Numerical Analysis. 3 Credits.

Numerical techniques for: the solution of equations in one or several unknowns, approximate integration, differential equations, approximation theory, optimization theory and matrix analysis. Corresponding error analysis will be investigated. Prerequisites: MATH 266 and a scientific programming language. F, odd years.

MATH 471. Introduction to Complex Variables. 3 Credits.

The complex plane, analytic functions, complex integration, power series, the theory of residues and contour integration, conformal mapping, Fourier and Laplace transformations, and applications. Prerequisite: MATH 265. F, even years.

MATH 477. Topics in Elementary School Mathematics. 1-3 Credits.

Selected topics from mathematical concepts appropriate to the elementary school curriculum. May be repeated for credit up to six credits. Prerequisite: Elementary education majors only. Repeatable to 6 credits. On demand.

MATH 479. Topics in Mathematics Education. 1-3 Credits.

Selected topics from mathematical concepts appropriate for K-12 educators. May be repeated for up to six credits. Prerequisite: Instructor consent. Repeatable to 6 credits. On demand.

MATH 488. Senior Capstone. 3 Credits.

This course is designed to help students transition into working mathematicians. Thus the course will address 1) written and oral expression of mathematical material and concepts, 2) research and problem solving in mathematics, and 3) technology in mathematics, and its appropriate use. Material will build on the core areas of calculus, linear algebra, and differential equations. Prerequisites: Senior standing with a major in mathematics. F.

MATH 494. Reading Course in Mathematics. 1-3 Credits.

Directed individual reading on selected topics not developed in other courses. Repeatable to six credits. Prerequisites: Consent of instructor. Repeatable to 6 credits. F,S,SS.

MATH 495. Readings in Mathematics. 1-3 Credits.

Directed individual reading on selected topics not developed in other courses. Repeatable to six credits. Prerequisite: Consent of instructor. Repeatable to 6 credits. F,S,SS.