

MATHEMATICS

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Maria Wehr

Undergraduate Degrees

Bachelor of Arts in Education (BAE)

- Mathematics/Elementary (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-elementary-bae>)
- Mathematics/Elementary Major and Middle Level Endorsement Option (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-elementary-middle-level-endorsement-option-bae>)
- Mathematics/Secondary (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-secondary-bae>) See CARR for advising.
- Mathematics (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-middle-level-bae>) Middle Level (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-middle-level-bae>)

Bachelor of Science (BS)

- Mathematics (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-bs>)

Undergraduate Minors

- Mathematics (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-minor>)
- Mathematics/Elementary (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-elementary-minor>)
- Mathematics/Secondary Middle Level Endorsement (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/mathematics-secondary-middle-level-endorsement-minor>)

Undergraduate Programs

Mathematics is both an art and a science: it has the unique feature that, while it is typically studied for its own sake, throughout history its results have been crucial in the advancement of other sciences. Presently there is a shortage of American mathematicians. Many professionals at the forefront of the behavioral, social and pure sciences also must have a solid background in advanced mathematics.

Among the degrees offered by the department is the Bachelor of Science degree in Mathematics. Students who enroll in this program may choose electives in other disciplines, in order to equip themselves for work in industry. They may also choose their electives from mathematics courses in order to prepare them for graduate work in mathematics or related disciplines; examples of related fields students have gone on to study in graduate school include statistics and economics. The program leading to the BS in mathematics is especially strong and is unique within the region. The department strives to promote excellence; it fields teams for the Putnam competition and prepares students for actuarial exams. It also sponsors a chapter of the mathematical honorary society, Pi Mu Epsilon. Recent graduates are successfully pursuing doctoral work at top-level universities.

The other major programs offered by the department lead to the Bachelor of Arts in Education; the BAE can be earned in Secondary Mathematics Education or Elementary Mathematics Education. In addition, a student may earn a Middle Level Endorsement in Mathematics Education. The preparation of mathematics teachers is a major emphasis of the department. Six department faculty members have expertise in mathematics education and experience teaching elementary, middle and/or high school mathematics. Employment opportunities for teaching mathematics at elementary, middle and secondary levels are substantial and expected to remain high for the foreseeable future.

The department's mathematics education programs prepare future teachers by providing background in mathematics content, teaching methods, learning theories, problem solving, the use of technology in teaching mathematics and current developments in curriculum. The secondary mathematics education program is one of the strongest in the state and provides students with a mathematics background that approaches that of the BS in mathematics. Completion of a major in secondary mathematics education satisfies the current requirements for a secondary mathematics teaching endorsement (certificate) for the state of Washington. The elementary mathematics education program is unique in the state; it provides a balance of mathematics content and teaching methods courses to give prospective K-8 teachers a deeper background in mathematics and the teaching of K-8 mathematics. Graduates of this program have the background to be mathematics content specialists at the elementary school level. The middle level endorsement secondary or elementary program options meet the state requirements for mathematics certification at the 4th through 9th grade levels.

The department has been strengthening its faculty and its faculty members are increasingly active in research. On occasion, undergraduates have been involved in research. Currently, faculty members are active in the areas of statistics, higher algebra, real and harmonic analysis, numerical analysis, complex variables, differential geometry, convexity, topology, biomathematics, computational neuroscience, mathematical physiology, reliability engineering, big data and time series analysis and in various areas of mathematics education including functions, number sense in primary children, construction of mathematical understanding, teachers' mathematical knowledge for

teaching, development of mathematics tasks, professional development of secondary mathematics teachers, and mathematical habits of mind.

An important function of the department is to provide services to students from a wide range of disciplines. Mathematics tutoring labs provide employment for high-achieving students and assistance to students in all mathematics courses.

In addition, computers equipped with mathematics software and tutorials are used in conjunction with several courses offered by the department and allow students the practice needed to be successful in their mathematics courses.

General Admissions Requirements for Mathematics

High school students who want to pursue a major in this department (except the BAE elementary mathematics) should complete four years of high school mathematics, which includes two years of algebra, one year of geometry and one year of pre-calculus mathematics. All prospective department majors should contact the Department of Mathematics office as soon as possible after being admitted to EWU to obtain an advisor and to plan a program of study.

Transfer students should contact their counseling office or the EWU Department of Mathematics to identify appropriate lower-division and major/minor preparatory courses.

Placement Assessment Policy

All students admitted to Eastern Washington University without a direct transfer degree must take the mathematics placement assessment (ALEKS) prior to registering for classes at Eastern. The only exceptions are the following: a. students who have received a grade ≥ 2.0 from a post-secondary institution in a course equivalent to the level of Intermediate Algebra or above; or b. students who have received a score ≥ 3.0 on the College Board's Advanced Placement Calculus AB or BC test, or the Advanced Placement Statistics test.

EWU uses placement software called ALEKS to ensure success in mathematics. Payment and sign up are done online through the math placement site (<http://ewu.edu/mathplacement>).

A photo ID is required at testing time. No calculators are allowed. The math placement assessment may be retaken once per cohort. Please refer to FAQ on the EWU math placement assessment site for complete information. For questions or more information contact the Department of Mathematics (<http://www.ewu.edu/cstem/programs/mathematics>) (509.359.6225).

Prerequisite Policy

Students must have earned a grade ≥ 2.0 or better in any course that is to be used to satisfy a prerequisite requirement for a subsequent mathematics course offered by the Eastern Washington University Department of Mathematics.

Academic Progress Policy for Math Majors and Minors

The intent of the Academic Progress Policy is to support Department of Mathematics declared majors and minors who experience difficulty in mathematics courses required in their programs. Department experience has shown that with very few exceptions, requiring a student who has failed to earn a grade ≥ 2.0 in a required mathematics course to meet with an advisor will be beneficial to the student in terms of maximizing the student's academic performance and minimizing the expected time to graduation.

A mathematics student is any Eastern Washington University student who intends to complete a major or minor in mathematics; mathematics with an option in computer science, economics, or statistics; mathematics/secondary; or mathematics/elementary.

Mathematics students who fail to make at least a grade ≥ 2.0 in any mathematics course taken at EWU must review the circumstances with an academic advisor during the term following the failure. A letter from the student explaining the circumstances must be placed in the student's file. Mathematics students failing to follow this procedure will not be allowed to enroll in subsequent mathematics courses.

Mathematics students who fail to make at least a grade ≥ 2.0 in mathematics courses taken at EWU on any two quarters during their undergraduate program must meet during the term following the second occurrence with a committee consisting of the student's appointed advisor and two other members of the mathematics faculty: one designated by the department chair and one chosen by the student. The committee will review the circumstances including the letter submitted after the first occurrence and recommend one of the following actions:

- the student be allowed to continue in the program without specific remediation;
- the student be required to remediate specific deficiencies in a way prescribed by the committee.

Mathematics students who fail to make at least a grade ≥ 2.0 in mathematics courses in three quarters during their undergraduate program must again meet with a committee of at least three faculty members who will decide if the student will be allowed to continue in the program. Students who are dropped from mathematics programs may be reinstated only by demonstrating the capability of academic excellence and a commitment to complete an undergraduate program in a reasonable time frame. This demonstration must be made before a committee of at least three members of the mathematics faculty.

Mathematics students who are dropped from mathematics programs will not be allowed to take subsequent mathematics courses except for those courses required by another department in the student's major program. The Department of Mathematics will not submit a letter of recommendation for Professional Degree Candidacy for any student who has been dropped from departmental programs.

Graduation Requirement

Students must receive a grade ≥ 2.0 in each mathematics course used to satisfy the requirements of an undergraduate major or minor in mathematics.

Required courses in the following programs of study may have prerequisites. Reference the course description section for clarification.

Graduate Certificates

- Middle-Level Mathematics Endorsement (<http://catalog.ewu.edu/archives/2016-2017/science-technology-engineering-mathematics/mathematics/middle-level-endorsement-certificate>)

Subject codes:

Developmental Mathematics (MTHD) (p. 3)
Mathematics (MATH) (p. 3)
Mathematics Education (MTED) (p. 8)

Developmental Mathematics Courses

MTHD 103. BASIC ALGEBRA/COLLEGE STUDENTS. 5 Credits.

Notes: this course is a substitution for the previous MATH 103 and 103A&B; graded Pass/No Credit.; does not count toward the 180 credit requirement.

Topics include algebraic properties of number systems, the algebra of polynomials, and algebraic, graphical and numerical solutions to equations of the first and second degree (as well as absolute value equations and literal equations).

MTHD 104. INTERMEDIATE ALGEBRA/COLLEGE STUDENTS. 5 Credits.

Notes: this course is a substitution for the previous MATH 104 and 104A&B; does not count toward the 180 credit requirement.

Pre-requisites: approved score in MTHD 103 or mathematics placement test or ≥ 2.0 in approved transfer course.

Topics are fundamentals of algebra, including rational equations; and radical, quadratic and exponential functions and equations.

MTHD 106. ALGEBRA REASONING. 5 Credits.

Notes: intended for students who are planning to use MATH 107 to complete the university proficiency in mathematics; does not count toward the 180 credit requirement.

Pre-requisites: approved score in MTHD 103 or placement test score equivalent to placement into MTHD 104.

Satisfies: completion of this course with a grade ≥ 2.0 satisfies pre university basic skill.

This course leads to mastery of basic algebraic skills involving linear models, systems of equations, proportional reasoning, and exponential growth. Students develop reasoning skills in the areas of problem solving, unit conversion, graphical interpretation, counting strategies and interpreting slopes.

MTHD 196. EXPERIMENTAL COURSE. 5 Credits.

Experimental

Mathematics Courses

MATH 107. MATHEMATICAL REASONING. 5 Credits.

Pre-requisites: MTHD 104 or MTHD 106 or equivalent course, or a satisfactory score on the mathematics placement test (MPT); Computer Literacy Competency recommended.

Satisfies: completion of this course with a grade ≥ 2.0 satisfies the university proficiencies in mathematics.

The course explores sets, basic logic, truth tables, elementary probability and statistics, geometry and the connections between mathematics and art, exponential functions, logarithms and geometric series. The spirit of the course is one of reasoning and problem solving. This is a terminal course intended for students not taking any other mathematics courses for their program of study. This proficiency may be satisfied by examination.

MATH 114. ALGEBRA CONCEPTS. 5 Credits.

Notes: completion of this course with a grade ≥ 2.0 or better satisfies mathematics competency.

Pre-requisites: grade ≥ 2.0 or better in MTHD 104, or a satisfactory score on the mathematics placement test (MPT).

This course provides an in depth treatment of quadratic and exponential functions. Linear and logarithmic functions are also studied and rate of change of a function is introduced. Problem solving, use of graphing tools, and quantitative and abstract reasoning are emphasized throughout the course.

MATH 121. INTRODUCTORY STATISTICS. 5 Credits.

Pre-requisites: MTHD 104 or MTHD 106 or a satisfactory score on the mathematics placement test.

Satisfies: completion of this course with a grade ≥ 2.0 satisfies the university proficiencies in mathematics.

This course develops statistical literacy and the ability to think statistically, and understand how probability plays a role in statistical inference. Descriptive statistics and their graphical representations are used to summarize real and simulated data sets. Students understand how the variation present in a population affects the precision of estimates of population attributes. Confidence intervals and hypothesis testing are introduced, with an emphasis on understanding their use in context.

MATH 141. PRECALCULUS I. 5 Credits.

Pre-requisites: MATH 114 or equivalent course or a grade ≥ 3.0 in MTHD 104 or a satisfactory score on the mathematics placement test (MPT).

This course includes modeling, rates of change and structure of functions; especially polynomial, rational, logarithmic and exponential. Problem solving, use of graphing tools and abstract reasoning are emphasized throughout the course.

MATH 142. PRECALCULUS II. 5 Credits.

Pre-requisites: MATH 141 or equivalent.

Satisfies: completion of this course with a grade ≥ 2.0 satisfies the university proficiencies in mathematics.

This course includes an in depth treatment of trigonometric and inverse trigonometric functions, identities, complex numbers, sequences, series, conic sections and mathematical induction. Polar coordinates, parametric equations and vectors are introduced. Problem solving, use of graphing tools, and quantitative and abstract reasoning are emphasized throughout the course.

MATH 161. CALCULUS I. 5 Credits.

Notes: for the university proficiencies, course may be substituted for MATH 107.

Pre-requisites: MATH 142 and ENGL 100.

A review of the concepts of functions, absolute value, open and closed intervals and solutions of inequalities. Limits, derivatives of single variable functions and their applications, anti-derivatives, the definite and integral.

MATH 162. CALCULUS II. 5 Credits.

Pre-requisites: MATH 161.

Applications of the definite integral, inverse functions, transcendental functions, techniques of integration, improper integrals, Taylor's formula.

MATH 163. CALCULUS III. 5 Credits.

Pre-requisites: MATH 162.

Polar coordinates, a brief treatment of conic sections, vectors, in R^2 and R^3 , parametric equations, introduction to partial differentiation, sequences and series.

MATH 196. EXPERIMENTAL COURSE. 1-5 Credits.

MATH 199. SPECIAL STUDIES. 1-5 Credits.

Notes: does not count toward the 180 credit requirement.

Pre-requisites: permission of the instructor, department chair and college dean.

MATH 200. FINITE MATHEMATICS. 5 Credits.

Notes: for the university proficiencies, the course may be substituted for MATH 107.

Pre-requisites: MATH 114 or equivalent course, or a grade ≥ 3.0 in MTHD 104, or a satisfactory score on the mathematics placement test (MPT); Computer Literacy Competency recommended; ENGL 100 or placement into or above ENGL 101.

This course provides an introduction to the mathematical systems encountered in the study of the behavioral sciences and a study of matrices, linear systems, linear programming, set theory and probability.

MATH 211. STRUCTURE OF ELEMENTARY MATH I. 5 Credits.

Notes: for the university proficiencies, the completion of MATH 211 and MATH 212 may be substituted for MATH 107.

Pre-requisites: MATH 114 or equivalent course, or a 3.0 or better in MTHD 104, or a satisfactory score on the mathematics placement test (MPT); ENGL 100 or placement into or above ENGL 101 on the EWU Writing Test.

This course is designed to give future K–8 teachers a basis for understanding elementary school mathematics. Topics include sets, number systems, functions and relations, operations on whole numbers, decimals and fractions, integers, percents, ratio and proportions and data analysis. There is a strong emphasis on conceptual understanding and problem solving.

MATH 212. STRUCTURE OF ELEMENTARY MATH II. 5 Credits.

Notes: for the university proficiencies, the completion of MATH 211 and MATH 212 may be substituted for MATH 107.

Pre-requisites: MATH 211. The course is designed to give future K–8 teachers a basis for understanding elementary school mathematics. Course topics include probability (including simple and complex experiments and fundamental counting principles), geometry (including relationships, symmetry and transformations) and measurement. All topics are approached from theoretical and practical perspectives.

MATH 225. FOUNDATIONS OF MATHEMATICS. 5 Credits.

Notes: you may not receive credit for both MATH 225 and MATH 301.

Pre-requisites: MATH 161.

Provides a transition from freshman-level to higher-level mathematics and is required for higher-level courses. Topics include logic, methods of proof, set theory, relations and functions and cardinality.

MATH 231. LINEAR ALGEBRA. 5 Credits.

Pre-requisites: MATH 142.

Theory and practice of vector geometry in R^2 and R^3 , systems of linear equations, matrix algebra, determinants, vector spaces, bases and dimension, linear transformations, eigenvalues and eigenvectors, rank and nullity and applications.

MATH 241. CALCULUS IV. 5 Credits.

Pre-requisites: MATH 163.

Differentiation of functions of several variables, multiple integrals, vector calculus. This course should be taken immediately after MATH 163, when possible.

MATH 296. EXPERIMENTAL COURSE. 1-5 Credits.**MATH 297. WORKSHOP, SHORT COURSE, CONFERENCE, SEMINAR. 3-5 Credits.****MATH 298. SEMINAR. 1-5 Credits.****MATH 299. SPECIAL STUDIES. 1-5 Credits.**

Pre-requisites: permission of the instructor, department chair and college dean.

MATH 301. DISCRETE MATHEMATICS. 5 Credits.

Notes: for the university proficiencies, the course may be substituted for MATH 107; you may not receive credit for both MATH 225 and MATH 301.

Pre-requisites: MATH 142.

This course covers the theory and application of the mathematics most relevant to computer science. Foundation topics include logic, induction and recursion, methods of proof, set theory, relations and functions, and combinatorics. Implementation topics include graphs and matrices, including systems of linear equations, two dimensional rotation matrices and matrix representations of graphs, as well as selected topics in graph theory.

MATH 307. MATHEMATICAL COMPUTING LABORATORY III. 1 Credit.

Notes: the laboratory may be repeated for credit.

Pre-requisites: successful completion of CPLA 100 and 101 or CPLA 120 and permission of the instructor.

The laboratory consists of exercises, experiments and reports, using applications, calculators or mathematical software such as Maple, Mathematica, Matlab, MINITAB, Geometer's Sketchpad or SAS, on topics closely related to the contents of the designated concurrent mathematics course. However, the laboratory is not required by the designated course. The topics are specified in the section subtitles.

MATH 311. FUNCTIONS AND RELATIONS FOR K-8 TEACHERS. 5 Credits.

Pre-requisites: MATH 114 or equivalent or satisfactory score on MPT; MATH 211 and MATH 212; CPLA 100 and CPLA 101 or equivalent.

A discussion of the algebraic concepts of functions and relations from numeric, graphic and symbolic viewpoints.

MATH 312. GEOMETRY FOR THE K-8 TEACHER. 5 Credits.

Pre-requisites: MATH 212.

Concepts from two- and three-dimensional geometry are explored and demonstrated. The course includes geometric proofs and requires the use of technology widely used in the K–12 system (and available in the Mathematics Department).

MATH 320. HISTORY OF MATHEMATICS. 4 Credits.

Pre-requisites: ENGL 201; MATH 225 or permission of the instructor.

A historical development of mathematical ideas and methods. Emphasizes the individuals involved, the development of the intellectual activity called mathematics and the ebb and flow of mathematics in history.

MATH 331. DISCRETE MATHEMATICS WITH APPLICATIONS. 5 Credits.

Pre-requisites: MATH 225 or both MATH 161 and MATH 301.

Graph theory, chaos theory and fractals, combinatorics, combinatorial game theory and the surreal numbers. Selected applications for each topic.

MATH 332. NUMBER THEORY. 5 Credits.

Pre-requisites: MATH 225.

Arithmetic in different bases, fundamental theorem of arithmetic, modular arithmetic, Wilson's and Fermat's theorems, RSA codes, perfect numbers, linear and quadratic congruences, quadratic reciprocity, Pythagorean triples, Gaussian integers and arithmetic in other settings, Fermat's last theorem and the method of descent.

MATH 341. TOPICS IN APPLIED ANALYSIS I. 4 Credits.

Pre-requisites: for MATH 341: MATH 163; for MATH 342 and MATH 343: MATH 241.

Selected topics in applied mathematics such as vector analysis, complex variables, partial differential equations, etc.

MATH 342. TOPICS IN APPLIED ANALYSIS II. 5 Credits.**Pre-requisites:** MATH 241.

Selected topics in applied mathematics such as vector analysis, complex variables, partial differential equations, etc.

MATH 343. TOPICS IN APPLIED ANALYSIS III. 4 Credits.**Pre-requisites:** for MATH 341: MATH 163; for MATH 342 and MATH 343: MATH 241.

Selected topics in applied mathematics such as vector analysis, complex variables, partial differential equations, etc.

MATH 347. INTRODUCTORY DIFFERENTIAL EQUATIONS. 4 Credits.**Pre-requisites:** MATH 163.

An introduction to ordinary differential equations, a nonrigorous, problem-solving approach including Laplace transforms and Fourier series with applications.

MATH 370. SURVEY OF GEOMETRIES. 5 Credits.**Pre-requisites:** CPLA 100 and CPLA 101 or equivalent; and MATH 225.

Introduction to various finite and infinite geometries, both Euclidean and non-Euclidean. The logical notions of consistency, independence, interpretation and models and completeness will be explored. Properties and theorems of each geometric system will be developed synthetically, analytically and through use of technology.

MATH 380. ELEMENTARY PROBABILITY AND STATISTICS. 5 Credits.**Notes:** for the university proficiencies, course may be substituted for MATH 107.**Pre-requisites:** MATH 141 or Mathematics Proficiency Clearance, Computer Literacy Competency recommended.

Empirical and theoretical frequency distributions. Discrete and continuous random variables. The binomial random variable and the normal. Descriptive statistics including measures of location, spread and association. An introduction to inferential statistics including confidence intervals and hypothesis testing.

MATH 385. PROBABILITY AND STATISTICAL INFERENCE I. 5 Credits.**Pre-requisites:** MATH 163 and MATH 225 or permission of the instructor.

This course introduces mathematical theory of probability and statistical inference. This includes proofs of simple theorems, applications of probability to real world problems, discrete and continuous random variables and their probability distributions, sampling distributions and the central limit theorem, basic properties of estimators including bias, constructions of confidence intervals and hypothesis tests.

MATH 387. REGRESSION CONCEPTS. 3 Credits.**Pre-requisites:** MATH 385.

This course is designed to provide an introduction, development and applications of regression concepts including Type 1 and Type 2 errors, statistical power, p-values, t-tests, F-tests, linear and polynomial regression, stepwise regression and the relationship between correlation and regression. Technology will be used throughout the course.

MATH 395. CO-OP FIELDWORK. 1-5 Credits.**MATH 396. EXPERIMENTAL COURSE. 1-5 Credits.****MATH 399. SPECIAL STUDIES IN MATH. 1-5 Credits.****Pre-requisites:** permission of the instructor, department chair and college dean.**MATH 401. ADVANCED FORMAL LOGIC. 5 Credits.****Pre-requisites:** PHIL 301 or math equivalent and successful completion of ENGL 101 and recommended placement above MTHD 104 on the mathematics placement test or MTHD 104 or equivalent.

Advanced study of formal deductive systems. Develops predicate logic on a rigorous basis, establishes some important metatheorems for logical systems and introduces some concepts in semantics and issues in the philosophy of logic.

MATH 407. MATHEMATICAL COMPUTING LABORATORY IV. 1 Credit.**Notes:** the laboratory may be repeated for credit.**Pre-requisites:** successful completion of successful completion of CPLA 100 and 101 or CPLA 120 and permission of the instructor.

The laboratory consists of exercises, experiments and reports, using applications, calculators or mathematical software such as Maple, Mathematica, Matlab, MINITAB, Geometer's Sketchpad or SAS, on topics closely related to the contents of the designated concurrent mathematics course. However, the laboratory is not required by the designated course. The topics are specified in the section subtitles.

MATH 411. DISCRETE MATHEMATICS FOR K-8 TEACHERS. 4 Credits.**Pre-requisites:** MATH 161 or MATH 311.

This course introduces the elementary mathematics major to the process of doing mathematics via mathematical proofs and mathematical reasoning. Throughout the course, familiar topics will be approached in a less intuitive, more formal way and in greater depth than previously experienced. Topics to be covered include logic; sets, functions and sequences; methods of proof; and combinatorics.

MATH 413. DATA ANALYSIS AND PROBABILITY FOR MIDDLE LEVEL TEACHERS. 3 Credits.**Pre-requisites:** MATH 212 and MATH 311; MTED 412 or concurrent enrollment.

Through readings, discussion and a hands-on problem-centered approach, students develop a profound understanding of concepts of data analysis and probability. Students deepen their understanding of the research on the teaching and learning of data analysis and probability in K-9 mathematics.

MATH 416. CALCULUS FOR MIDDLE LEVEL TEACHERS. 4 Credits.**Pre-requisites:** MATH 141 or MATH 311.

This course is intended for pre-service middle school teachers and focuses on conceptual and procedural understandings of limit, continuity, differentiation and integration. It includes the techniques and applications of calculus and use of technology to explore and represent fundamental concepts of calculus.

MATH 420. PROBLEM SOLVING FOR K-8 TEACHERS. 4 Credits.**Pre-requisites:** MTED 390 (or math teaching experience) and MATH 311 or equivalent course approved by the department and CPLA 100 and CPLA 101 or the equivalent.

This math content course for prospective K-8 teachers requires students enrolled in the class to solve a large variety of problem-solving problems using a variety of strategies including the use of manipulatives, technology and mathematical representations. Techniques for teaching problem solving are discussed in the course. The use of a variety of types of technology is a required component of the course.

MATH 430. ADVANCED LINEAR ALGEBRA. 5 Credits.**Pre-requisites:** MATH 225 and MATH 231.

This course provides an advanced study of linear algebra. Topics will be Jordan decomposition, inner product spaces, hermitian operators. Applications to other branches of mathematics, physics and chemistry will be included.

MATH 431. APPLIED GROUP THEORY. 5 Credits.**Pre-requisites:** MATH 225 and MATH 231.

Groups, cyclic and permutation groups, cosets and Lagrange's theorem, Cayley graphs, group actions, counting theorems with applications, tilings and groups of symmetries with applications.

MATH 432. RINGS AND POLYNOMIALS. 5 Credits.**Pre-requisites:** MATH 225 and MATH 231.

Binary operations and algebras, rings and polynomials, factor rings and ideals, integral domains and fields (both finite and infinite), factor theorems, prime, irreducible and unique factorization, power series and differential operators, applications including computer algebra techniques, digital communication and encryption.

MATH 433. GALOIS THEORY. 5 Credits.**Pre-requisites:** MATH 432.

Field theory, splitting fields, Galois groups, fundamental theorem of Galois theory, applications to classical problems of Euclidean constructibility and solvability by radicals, applications of the theory to encryption and digital communication.

MATH 444. NUMERICAL LINEAR ALGEBRA. 5 Credits.**Pre-requisites:** junior, senior or graduate standing; MATH 161 and MATH 231.

This course develops numerical linear algebra and error estimates essential for scientific computing: machine arithmetic, algorithms for solving systems of linear equations, algorithms for computing eigenvalues and singular values (LU, QR, Jacobi's and SVD) and the theory of error estimates through condition numbers and backward analysis. The course also includes such topics as the design and analysis of algorithms for floating-point arithmetic, linear regression, orthogonal linear regression, linear programming, or cubic splines, with applications to engineering and the sciences. Typical applications are Google PageRank, Kalman filtering, data compression and image processing with wavelets. This course requires the use of computers and software available at EWU.

MATH 445. NUMERICAL ANALYSIS. 5 Credits.**Pre-requisites:** junior or higher standing; MATH 444.

The course combines numerical linear algebra with numerical differentiation and integration to derive methods of scientific computing: numerical differentiation and integration, existence, uniqueness, stability and numerical approximation of solutions to nonlinear systems and of ordinary or partial differential equations, splines and fast Fourier or wavelet transforms. The course also includes such applications to engineering and the sciences as the design and analysis of algorithms to compute special functions, computed geometric design, fluid dynamics, heat diffusion or financial Black-Scholes models, image processing or nonlinear regression.

MATH 447. DIFFERENTIAL EQUATIONS. 5 Credits.**Pre-requisites:** MATH 225, MATH 231 and MATH 347.

This course is an advanced study of ordinary differential equations focusing on linear and nonlinear systems, with analytical, qualitative, and numerical methods of solution including Euler's method, matrix exponential, stability, phase plane analysis, linearization, Lyapunov functions, existence and uniqueness and applications. This course provides experience with mathematical software.

MATH 448. PARTIAL DIFFERENTIAL EQUATIONS. 5 Credits.**Pre-requisites:** MATH 225 and either MATH 347 or MATH 444.

This course is an advanced study of partial differential equations via boundary value problems and Fourier series representations, centered on classical and numerical solutions of the heat equation, wave equation, advection equation and Laplace equation, introductory finite differences, modeling applications and use of technology through mathematical software. Selected topics may include Bessel's inequality, energy methods, existence and uniqueness, eigenfunction expansions and integral transforms.

MATH 460. CONTINUOUS FUNCTIONS. 5 Credits.**Pre-requisites:** MATH 163 and MATH 225.

The course lays out the foundations for calculus and analytical geometry; the course develops the topology of the n -dimensional real Euclidean space. Topics include the completeness of the real numbers, topological spaces, continuity and properties preserved by continuous functions: compactness and connectedness.

MATH 461. ADVANCED CALCULUS I. 5 Credits.**Pre-requisites:** MATH 241 and MATH 460.

This course applies notions from linear algebra and continuous functions to develop the calculus of functions of several variables. Topics include differentiability, the derivative as a linear transformation, extreme value problems and the implicit and inverse function theorems.

MATH 462. ADVANCED CALCULUS II. 5 Credits.**Pre-requisites:** MATH 461.

This course builds on topics introduced in MATH 461, and develops integration with differential forms. Topics include line integrals, exterior algebra and a general form of Stokes's theorem; the course includes selected applications to algebraic topology and fluid dynamics, if time permits.

MATH 470. FOUNDATIONS OF GEOMETRY. 5 Credits.**Pre-requisites:** MATH 225 and MATH 231 or concurrent enrollment.

The course includes the study of Euclidean and non-Euclidean isometries. Selected topics in advanced geometry stressing applications to other branches of mathematics, physics, chemistry and biology will be explored.

MATH 481. COMPLEX ANALYSIS. 5 Credits.**Notes:** MATH 225 and MATH 460 are recommended.**Pre-requisites:** MATH 163.

The course proves relations between derivatives, integrals along curves, Maclaurin series, and singularities of complex-valued functions of a complex variable, in particular, theorems of Abel, Cauchy-Goursat, Green, Laurent, Liouville, Morera, Riemann and Rouch. Applications include the solution of Laplace's partial differential equation by Green's functions (Cauchy's and Poisson's integral formulae) or Fourier Transforms. Detailed proofs of theorems also provide a theoretical foundations for the corresponding theorems from calculus with one or two variables: differentiation and integration of power series and Fourier series, differentiation relative to parameters of integrals along curves and the fundamental theorem of algebra.

MATH 485. PROBABILITY AND STATISTICAL INFERENCE II. 5 Credits.**Pre-requisites:** MATH 231, MATH 241 and MATH 385 or permission of the instructor.

This course covers a variety of statistical methods for research in the natural sciences, including analysis of variance, multiple regression, general linear models and nonparametric statistical procedures. One or more additional topics will be selected by the students in consultation with the instructor teaching the course. Use of statistical software will be emphasized.

MATH 486. PROBABILITY AND STATISTICAL INFERENCE III. 5 Credits.**Pre-requisites:** MATH 485 or permission of the instructor.

This course covers advanced topics in probability and statistical inference including discrete and continuous multivariate distributions, moment generating functions, proof of the central limit theorem, properties of estimators including efficiency and sufficiency, best linear unbiased estimators (BLUE), maximum likelihood estimation, the Neyman-Pearson lemma and likelihood ratio tests. The course concludes with a practical student-project component in which students apply methods learned to the analysis of a real-world data set.

MATH 491. SENIOR THESIS. 5 Credits.**Pre-requisites:** MATH 231, MATH 241, MATH 347, MATH 385, MATH 460.**Satisfies:** senior capstone university graduation requirement.

This course provides students with an opportunity to research a mathematical topic and present their findings in writing and orally.

MATH 492. PROBLEM SOLVING SEMINAR. 5 Credits.**Pre-requisites:** MATH 225 or permission of the instructor; MATH 380 or MATH 385.

The course examines various problem solving strategies and techniques for teaching problem solving at the secondary level such as direct proof, indirect proof, inferences, mathematical representations and the use of technology.

MATH 494. SENIOR SEMINAR. 2 Credits.**Pre-requisites:** for students pursuing the BA in Mathematics: prior or concurrent enrollment in MATH 462 and MATH 432; for students pursuing the BAE Secondary: prior or concurrent enrollment in MATH 432 and MTED 493.

The Senior Seminar course will explore the culture of mathematics through readings and classroom discussions. The students will be required to write a paper on some aspect of mathematics. At the same time, students will review the core mathematics they have studied and comprehensive tests will be administered in order to assess the knowledge they have acquired in their degree programs.

MATH 496. EXPERIMENTAL COURSE. 1-5 Credits.**MATH 497. WORKSHOP, SHORT COURSE, CONFERENCE, SEMINAR. 1-5 Credits.**

Selected topics to be arranged in consultation with the requesting organization.

MATH 498. SEMINAR. 1-5 Credits.**MATH 499. DIRECTED STUDY. 1-5 Credits.****Pre-requisites:** permission of the instructor, department chair and college dean.**MATH 507. MATHEMATICAL COMPUTING LABORATORY. 1 Credit.****Notes:** the laboratory may be repeated for credit.**Pre-requisites:** concurrent enrollment in or prior credit for a 500-level mathematics course designated by the Department of Mathematics each academic term.

The laboratory consists of exercises, experiments and reports, with applications or calculators or with such mathematical software as Maple, Mathematica, Matlab, MINITAB, Geometer's Sketchpad or SAS, on topics closely related to the contents of the designated concurrent mathematics course. However, the laboratory is not required by the designated course. The topics are specified in the section subtitles.

MATH 510. NUMBER SENSE FOR TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of the concepts of numeration systems, base ten and place value, operations, fractions, decimals, percents, integers, real numbers and number theory and will deepen their understanding of the research on the teaching and learning of these topics in K-9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to these number-sense topics.

MATH 511. RATIO AND PROPORTION - TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of the concepts of ratio and proportion and deepen their understanding of the research on the teaching and learning of ratio and proportion in K-9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to ratio and proportion.

MATH 512. GEOMETRIC REASONING - TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of geometry concepts and deepen their understanding of the research on the teaching and learning of geometry concepts in K-9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to geometry.

MATH 513. DATA ANALYSIS AND PROBABILITY FOR TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of concepts of data analysis and probability and deepen their understanding of the research on the teaching and learning of data analysis and probability in K-9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to data analysis and probability.

MATH 514. ALGEBRAIC REASONING - TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of algebraic reasoning and deepen their understanding of the research on the teaching and learning of algebraic reasoning in K-9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to algebraic reasoning.

MATH 515. MEASUREMENT FOR TEACHERS. 3 Credits.**Pre-requisites:** graduate standing.

Through readings, discussion and a hands-on problem-centered approach, students will develop a profound understanding of measurement concepts and deepen their understanding of the research on the teaching and learning of measurement in K–9 mathematics. Major emphases will be learners' cognitive development through and across different grade levels, including that of diverse and exceptional learners, typical student conceptions and misconceptions, meaningful use of representations and technology in developing understanding and state and national standards related to measurement.

MATH 516. CALCULUS FOR MIDDLE LEVEL TEACHERS. 4 Credits.**Pre-requisites:** graduate standing and MATH 311 or equivalent.

This course is intended for middle school teachers and focuses on conceptual and procedural understandings of limit, continuity, differentiation and integration. It includes the techniques and applications of calculus and use of technology to explore and represent fundamental concepts of calculus. It also addresses the historical development of calculus and the contributions to its development from many cultures. Students will create a project focusing on connections between calculus, the middle school curriculum and current understandings of how students learn mathematics.

MATH 528. PROBLEM-CENTERED LEARNING. 3 Credits.**Pre-requisites:** graduate standing.

This course explores how to create classroom environments where rich tasks form the basis for mathematical learning. Special emphasis will be placed on task construction, selection and problem-posing. Participants will engage in a series of non-routine problem-solving activities. They will also be expected to develop non-routine problem-solving activities addressing specific mathematical ideas. These activities will serve as a basis for examining and reflecting on the research about and the implications of such an approach to the teaching and learning of mathematics.

MATH 531. ALGEBRA I. 4 Credits.**Pre-requisites:** MATH 431 or permission of the instructor.

The theory of groups, starting at the Sylow Theorems. Topics: group actions, normal series, solvable and nilpotent groups, structure theorem for abelian groups, semidirect products, extensions.

MATH 539. SEMINAR IN SPECIAL TOPICS. 1-5 Credits.**MATH 573. TOPICS IN APPLIED MATHEMATICS. 4 Credits.****Notes:** may be repeated for credit.**Pre-requisites:** graduate standing or permission of the instructor.

The course focuses on the mathematics of applications, depending on the interests of the class and the instructor. Topics will be specified in the section subtitle.

MATH 581. COMPLEX ANALYSIS I. 4 Credits.

This course establishes the basic properties of holomorphic functions, including complex derivatives, power series, singularities, residues and the general integral formula of Cauchy. In particular, the course proves such classical results as the Fundamental Theorem of Algebra, the Open Mapping Theorem, the Maximum Principle and the theorems of Weierstrass, Montel or Looman-Menchoff. This course also presents examples of elementary conformal mappings, with optional applications to cartography or physics, from geometric or analytic points of view.

MATH 582. COMPLEX ANALYSIS II. 4 Credits.**Pre-requisites:** MATH 581.

Continues MATH 581 through the proofs of advanced results, such as the general Riemann Mapping Theorem, or properties of the special functions of Riemann and Weierstrass. If time permits, may include application to Algebraic Geometry, Number Theory and Coding or extensions to several complex variables, for example.

MATH 596. EXPERIMENTAL COURSE. 1-5 Credits.**MATH 597. WORKSHOP, SHORT COURSE, CONFERENCE, SEMINAR. 1-5 Credits.****Notes:** only one workshop course for up to 3 credits may be used to fulfill graduate degree requirements.**MATH 598. SEMINAR. 1-5 Credits.****Pre-requisites:** permission of the instructor.**MATH 599. DIRECTED STUDY. 1-6 Credits.****Pre-requisites:** permission of the instructor, department chair and college dean.**MATH 600. THESIS. 1-15 Credits.****Pre-requisites:** permission of the instructor, department chair and college dean.

A research thesis under the direction of a graduate committee.

MATH 601. RESEARCH REPORT. 1-15 Credits.**Pre-requisites:** permission of the instructor, department chair and college dean.

A research study in lieu of a bound thesis conducted as partial fulfillment of a master's degree in education under the direction of a graduate committee.

MATH 696. COLLEGE TEACHING INTERNSHIP. 1-5 Credits.

Teaching a lower-division college course under supervision of a regular faculty member. Includes course planning, arranging bibliographical and instructional aids, conferences with students, experience in classroom instruction and student course evaluation.

Mathematics Education Courses

MTED 290. EARLY MATH PRACTICUM. 3 Credits.**Pre-requisites:** MTED 390 or permission of Mathematics Education Committee.

This course is primarily an early field experience for students majoring in mathematics education. Students are in a classroom, co-plan and co-teach lessons, tutor students and participate in seminar.

MTED 299. DIRECTED/INDEPENDENT STUDY. 1-5 Credits.

Independent/Directed Study.

MTED 390. METHODS OF TEACHING ELEMENTARY SCHOOL MATHEMATICS. 5 Credits.**Pre-requisites:** MATH 211 and MATH 212 or department approved equivalents; EDUC 310 or concurrent enrollment.

This course is designed to teach current methods for teaching math (grades K–8).

MTED 392. METHODS OF TEACHING SECONDARY MATH I. 3 Credits.**Pre-requisites:** EDUC 200, MATH 225.

This course is designed to address the development and evaluation of select content and process standards involved in middle and early high school algebra: measurement, modeling, equivalence, algebraic manipulation, proportion and communication in middle and high school. It includes the use of traditional, technological and manipulative materials consistent with current theory and practice.

MTED 393. METHODS OF TEACHING SECONDARY MATHEMATICS II. 3 Credits.

Notes: if through communication with your major and minor advisors you determine that taking MTED 393 concurrently with EDUC 413 will result in an overload, please contact the instructor of MTED 393.

Pre-requisites: MTED 392 and concurrent enrollment in EDUC 413.

This course is designed to address the development and evaluation of select content and process standards involved in the preparation of students for calculus: variation, algebra, functions, rate of change and communication in high school. It includes the use of traditional, technological and manipulative materials consistent with current theory and practice.

MTED 396. EXPERIMENTAL. 1-5 Credits.

Experimental.

MTED 399. INDEPENDENT DIRECTED STUDY. 1-6 Credits.

Independent and directed study.

MTED 412. ADVANCED METHODS OF TEACHING K-8 MATHEMATICS. 5 Credits.**Pre-requisites:** MTED 390 and MATH 311 or MTED 493 or approval of the instructor; and CPLA 100 and CPLA 101 or the equivalent.

Advanced course in methods of teaching math (grades K–8), including the (required) use of technology. Focused on the teaching of topics in measurement, probability and statistics, algebraic reasoning, ratio and proportion and geometry.

MTED 490A. SENIOR CAPSTONE: ELEMENTARY PRACTICUM. 5 Credits.**Pre-requisites:** MTED 390 and MTED 412 and senior standing.**Satisfies:** senior capstone university graduation requirement.

This course is a practicum for students majoring in Mathematics Education. The students will do a pre-student teaching classroom experience in a K-12 mathematics classroom (3 credits) and participate in a seminar (2 credits). Lessons will be planned and taught. Emphasis will be on putting educational theory into practice and reflecting on the process, particularly in the areas of problem solving, the NCTM Standards, use of manipulative materials and assessment. MTED 490A will fulfill the Senior Capstone requirement for the BAE Math/Elementary majors, and MTED 490B will fulfill the Senior Capstone requirement for the BAE Math/Secondary majors.

MTED 490B. SENIOR CAPSTONE: SECONDARY PRACTICUM. 5 Credits.**Pre-requisites:** MTED 393 and senior standing.**Satisfies:** senior capstone university graduation requirement.

This course is a practicum for students majoring in Mathematics Education. The students will do a pre-student teaching classroom experience in a K-12 mathematics classroom (3 credits) and participate in a seminar (2 credits). Lessons will be planned and taught. Emphasis will be on putting educational theory into practice and reflecting on the process, particularly in the areas of problem solving, the NCTM Standards, use of manipulative materials and assessment. MTED 490A will fulfill the Senior Capstone requirement for the BAE Math/Elementary majors, and MTED 490B will fulfill the Senior Capstone requirement for the BAE Math/Secondary majors.

MTED 493. METHODS OF TEACHING SECONDARY MATHEMATICS III. 3 Credits.

Notes: if through communication with your major and minor advisors you determine that taking MTED 493 concurrently with EDUC 341 will result in an overload, please contact the instructor of MTED 493.

Pre-requisites: MTED 393, MATH 370 and MATH 380 or MATH 385. Concurrent: EDUC 341.

This course is designed to address the development and evaluation of select content and process standards—geometry, measurement, statistics, probability, problem solving, connections and communication in the middle and high school. The course includes the use of traditional, technological and manipulative materials consistent with current theory and practice.

MTED 499. DIRECTED STUDY. 1-5 Credits.

Directed Study.

MTED 525. ASSESSMENT AND MATHEMATICS LEARNING. 3 Credits.**Pre-requisites:** graduate standing.

This course explores the relationship between assessment and mathematics learning. In particular, we will focus on the forms and purposes of assessment in the mathematics classroom, including the alignment of assessment to instruction, use of multiple sources of assessment information as evidence of learning and appropriate methods. Through readings, discussion and a hands-on problem-centered approach, students will extend their understanding of the research on assessment and the roles of assessment in K–9 mathematics classrooms.

MTED 527. TECHNOLOGY IN MATH TEACHING. 3 Credits.**Pre-requisites:** graduate standing.

This course will explore the appropriate use of technology in mathematics education from philosophical, social, theoretical and pedagogical perspectives. It will provide perspectives on current and future trends and issues regarding the use of technology in mathematics teaching and learning. Students will use technology to solve mathematical problems, create mathematical demonstrations and construct new ideas of mathematics. Special attention is devoted to developing a deep understanding of the appropriate use of technology to explore and learn mathematics.

MTED 529. TOPICS IN MATH EDUCATION. 3 Credits.**Notes:** may be repeated for credit with different topics.**Pre-requisites:** graduate standing.

This course includes topics regarding the teaching and learning of mathematics selected depending on the interest of the class and instructor. Possible topics may include (but are not limited to): history and culture of mathematics, history of mathematics education, systems theory and learning and equity. Topics will be specified in the section subtitle.

MTED 590. MATH METHODS FOR ELEMENTARY TEACHERS. 5 Credits.**Pre-requisites:** bachelor's degree or permission of instructor.

Designed to expose participants to a variety of instructional techniques for teaching mathematics concepts and skills at the K–8 level. Strengths and weaknesses of different techniques, such as lecture demonstration, small-group activities and problem solving are modeled and discussed.

MTED 592. THEORY AND RESEARCH IN MATHEMATICS EDUCATION. 3 Credits.

Pre-requisites: graduate standing.

This course is designed for graduate students in mathematics education who intend to pursue or further teaching careers. This course will explore the history of research in mathematics education; discuss various theories of mathematics learning; evaluate, synthesize and critique mathematics education research; and become acquainted with a diverse sample of quantitative and qualitative studies in mathematics education, as well as, with issue of current interest within the community. The course will be focused on issues that mathematics teachers should understand and investigate; including both content and research methods. In addition, students will be expected to select a mathematics content and/or pedagogical topic for particular emphasis in the course and conduct a research review. Students will leave the course with an understanding of the history of mathematics education research and of the use of research to inform teaching practice.

MTED 599. INDEPENDENT STUDY. 1-6 Credits.**MTED 694. MATHEMATICS MIDDLE LEVEL TEACHING INTERNSHIP. 4 Credits.**

Pre-requisites: four courses from the MATH 510 to MATH 516 series and MTED 525 or MATH 528.

This course is a field experience in a middle level mathematics classroom. Candidates will demonstrate competency at designing and implementing mathematics instruction, guided by continuous formative assessment, that enables a broad diversity of learners to construct meaning, create and defend conjectures, solve problems, utilize procedures and notation, and monitor their learning.

MTED 695. MATHEMATICS EDUCATION INTERNSHIP. 6 Credits.

Pre-requisites: graduate standing; permission of the instructor, department chair and college dean.

The theories of teaching and learning mathematics explored in MATH 592 Theory and Research in Mathematics Education are made practically relevant in this course, as student teach classes such as MATH 211 or MATH 212 while being mentored by faculty having experience with those classes. One-hour weekly seminars complement the in-class teaching assignment.