2010-2011 Course Catalog

The University Of Montana

Department of Mathematical Sciences

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Mathematics is studied both as a tool and for its own sake. Its usefulness in the sciences - physical, biological, social, behavioral, and environmental - and in decision-making processes is so established as to make it an indispensable part of many curricula.

Mathematics is chosen as a major area of study by individuals who find it challenging, fascinating, and beautiful. It is also appreciated by many who seek primarily to use mathematics as a tool.

A career in mathematics, except for teaching at the secondary level, generally requires a graduate degree as preparation. Careers include teaching, research, and the application of mathematics to diverse problems in institutions of higher learning, business, industry, and government.

The Bachelor of Arts, Master of Arts, and Doctor of Philosophy degrees are offered as well as a Bachelor of Science in Mathematical Sciences–Computer Science.

High School Preparation: For studying mathematics at the university level, it is recommended that the high school course work consist of four years of college-preparatory mathematics, including geometry, trigonometry, and college algebra or precalculus. A course in calculus or statistics is helpful, but not necessary. It is unusual to complete an undergraduate degree in mathematics in four years without the necessary background to take Calculus I (M 171) during the freshman year (preferably during the first semester at the university).

Special Degree Requirements

Refer to graduation requirements listed previously in the catalog. See index.

Mathematics Requirements for B.A. Degree with a Major in Mathematical Sciences

To obtain a B.A. degree with a major in Mathematical Sciences, the required courses are M 171 or 181, 172 or 182, 221 (MATH 152, 153, 221), M 273 (MATH 251) (except for students in the Mathematics Education option), M 300 (MATH 300) (except for students in the Mathematics Education option), M 307 (MATH 305) and six additional courses from the following list (at least three of the six must be numbered 400 or

above): M 301, 311, 325, 326, 361, 362, 381, 412, 414, 429, 431, 432, 439, 440, 445, 472, 473, 485 and STAT 341, 421, 422 (MATH 301, 311, 325, 326, 341, 351, 381, 382, 406, 412, 414, 421, 422, 431, 441, 442, 451, 452, 471, 475, 485). All mathematical sciences courses counted toward the major must be passed with a grade of C– or better and a 2.00 grade point average is required for these courses. In addition, if a special option is desired, the minimum requirements listed below for that option must be met. Additional courses should be chosen in consultation with a mathematics advisor.

Requirements for the Special Options

Applied Mathematics Option

M 311, 412, 414 (MATH 311, 412, 414) and one of M 440 or 472 (MATH 452 or 471). (M 381 and 485 (MATH 351 and 485) are recommended.)

Combinatorics and Optimization Option

M 361, 362, 485 (MATH 381, 382, 485); and one course chosen from STAT 341 (MATH 341), M 414, 440 (MATH 414, 471), or CSCI 332 (CS 332).

Mathematics Education Option

M 301, 326, 429, 431, 439 (MATH 301, 326, 406, 421, 431), and STAT 341 (MATH 341); either M 273 (MATH 251) or one additional course chosen from the above list for the six-course requirement; and the completion of licensure requirements for teaching in secondary schools to include C&I 430.

Pure Mathematics Option

Four courses chosen from M 381, 431, 432, 472, 473 (MATH 351, 421, 422, 451, 452).

Statistics Option

STAT 341, 421, 422 (MATH 341, 441, 442). (Additional mathematics and statistics courses chosen with advisor.)

Major Requirements in Courses Outside Mathematics

1. Except for students in the Mathematics Education option and for students presenting a second major within the University, students must either complete a two-semester language sequence as specified under "Group III: Modern and Classical Languages" in the General Education section of the Catalog, or take two courses chosen from CSCI 100, 135, 136 (CS 101, 131, 132).
2. All mathematics majors, except those selecting the mathematics education option, must complete 18 credits in at most three sciences selected from astronomy, biology, chemistry, computer science, economics, forestry, geology, management, microbiology, and physics. Students selecting the mathematics education option must complete 12 credits in at most two sciences selected from astronomy, biology, chemistry, computer science, geology, microbiology and physics. An alternative to the science requirement is for the student to present a minor or second major within

the University, or for the student with a mathematics education option to complete an additional teaching minor or major.

3. The upper–division writing requirement for Mathematical Sciences majors consists of: M 429 (Math 406), or any other approved General Education upper–division Writing course, or a senior thesis (M 499 (MATH 499)).

Requirements for a B.S. Degree with a Combined Major in Mathematical Sciences–Computer Science

The purpose for the combined program is to provide a thorough background in both allied disciplines and to inculcate a deeper understanding of their goals and methods. A student must complete 60 credits in the two disciplines: 30 of these credits in mathematical sciences courses and 30 of these credits in computer science courses. A minimum grade of "C–" and a 2.0 grade point average is required in all courses which follow.

The mathematical sciences requirements are: M 171 (or 181), 172 (or 182), 221, 273, 307 (or 225) (MATH 152,153, 221, 251, 305 (or 225)), and twelve credits of mathematical sciences courses selected from the following list: M 311, 325, 326, 361, 362, 381, 412, 414, 429, 431, 432, 439, 440, 445, 472, 473, 485 and STAT 341, 421, 422, 451, 452 (MATH 311, 325, 326, 341, 351, 381, 382, 406, 412, 414, 421, 422, 431, 441, 442, 444, 445, 451, 452, 471, 475, 485).

The computer science requirements are: CSCI 106, 135-136 or 137, 205, 232, 332, 361 (CS 121, 131–132 or 133, 242, 241, 332, 281) and nine credits of CSCI (CS) electives selected from courses numbered 300 and above. A total of at most three of the nine credits of CSCI (CS) electives may be in CSCI 398 or 498 (CS 398 or 498). The combined nine additional credits of computer science electives and twelve additional credits of mathematical sciences electives must include at least three 3– or 4–credit courses numbered 400 or above, with at least one chosen from each department (not including M 429 (MATH 406) and STAT 451, 452 (MATH 444 and 445)).

Other requirements are: One of the sequences BIOB 160N, 170N, 171N (BIOL 110N, 108N, 109N); CHMY 141N, 143N (CHEM 161N, 162N); or PHSX 215N-218N (PHYS 211N–214N). In addition, WRIT 222 (FOR 220), and either COMM 111A or COMM 242.

Each student plans a program in consultation with a computer science and a mathematical sciences advisor. Students planning to attend graduate school in computer science or the mathematical sciences should consult with their respective advisors.

The upper–division writing requirement is one of the following: CSCI 315E (CS 415E), M 429 (MATH 406), any other approved General Education upper–division writing course, or a senior thesis (CSCI 499 (CS 499) or M 499 (MATH 499)).

Suggested Curricula: Applied Math–Scientific Programming: M 311, 412, 414 (MATH 311, 412, 414), and one course chosen from STAT 341 (MATH 341), M 381, 473, 472, 440 (MATH 351, 451, 452, 471). Three courses chosen from CSCI 460, 441, 477, 444 (CS 344, 446, 477, 486). Combinatorics and Optimization–Artificial Intelligence: M 361, 362 (MATH 381, 382), and two courses chosen from M 325, 414, 485 (MATH 325, 414, 485) and STAT 341 (MATH 341); and CSCI 460, 446, and 447 (CS 344, 455, and 457). Statistics–Machine Learning: STAT 341, 421 (MATH 341, 441), and two courses chosen from M 325, 362, 485 (MATH 325, 382, 485) and STAT 422 (MATH 442). Three courses chosen from CSCI 340, 446, 447, 451, and 444 (CS 365, 455, 457, 458,

and 486). Algebra–Analysis: M 381, 431 (MATH 351, 421), and two courses chosen from M 326, 432, 473, 472 (MATH 326, 422, 451, 452); CSCI 460, 426 (CS 344, 441), and one other course.

Suggested Course of Study

First Year	A	S
M 171-172 or 181-182 (MATH 152-153) Calculus I, II or Honors Calculus I, II	4	4
WRIT 101 (ENEX 101) Composition and other General Education Courses (including two sciences courses)	12	12
	16	16
Second Year	**A**	**S**
M 221 (MATH 221) Introduction to Linear Algebra	4	–
M 273 (MATH 251) Multivariable Calculus	4	–
M 307 (MATH 305) Introduction to Abstract Mathematics	–	3
General Education courses, additional science courses and electives	9	13
	17	16

Requirements for a Minor

To earn a minor in mathematics the student must earn 23 credits in M, MATH, or STAT courses listed in a UM-Missoula Catalog (or in transfer courses equivalent to such courses). M courses must be numbered 115 or higher, and MATH courses must be numbered 111 or higher. Courses must include: (a) one of M 162 or 172 or 182 (MATH 150 or 153), and (b) at least three 3– or 4– credit courses at the 300 level or above. M 172 or 182 (MATH 153) (Calculus II) is recommended since it is a prerequisite for many upper–division mathematics courses. All courses counted toward the minor must be passed with a grade of C– or better and a 2.00 grade point average is required for these courses. A handout with detailed advice for math minors, including suggested curricula, is available on the math department's home page.

Mathematics Education Minor: For a teaching minor endorsement in the field of mathematics, a student must complete M 171-172, 221, 301, 307, 326, 439 (MATH 152-153, 221, 301, 305, 326, 431), and STAT 341 (MATH 341). Students also must complete C&I 430, gain admission to Teacher Education Programs and meet the

requirements for teaching licensure (see the Department of Curriculum and Instruction section of this catalog). All courses counted toward the minor must be passed with a letter grade of C– or better.

Courses

U = for undergraduate credit only, UG = for undergraduate or graduate credit, G = for graduate credit. R after the credit indicates the course may be repeated for credit to the maximum indicated after the R. Credits beyond this maximum do not count toward a degree.

Mathematical Sciences (M)

Unless the student has prior written approval of the Mathematical Sciences Department, credit is not allowed for any mathematics course that is a prerequisite for a mathematics course for which credit has already been earned. Students receiving transfer or Advanced Placement credit for STAT 216 (MATH 241) may take M 115 (MATH 117) for credit. See the College of Technology section for Introductory Algebra, M 090 (MAT 005), and Intermediate Algebra, M 095 (MAT 100).

U 104 (MATH 109) Numbers as News 3 cr. Offered spring. Prereq., M 090 (MAT 005) with a grade of B- or better, or M 095 (MAT 100), or appropriate placement score. An exploration of mathematics and statistics as used in the popular media. For students in the School of Journalism only.

U 105 (MATH 107) Contemporary Mathematics 3 cr. Offered every term. Prereq., M 090 (MAT 005) with a grade of B- or better, or M 095 (MAT 100), or appropriate placement score. An introduction to mathematical ideas and their impact on society. Intended for students wishing to satisfy the general education mathematics requirement.

U 115 (MATH 117; MAT 117) Probability and Linear Mathematics 3 cr. Offered every term. Prereq., M 090 (MAT 005) with a grade of B- or better, or M 095 (MAT 100), or appropriate placement score. Systems of linear equations and matrix algebra. Introduction to probability with emphasis on models and probabilistic reasoning. Examples of applications of the material in many fields.

U 121 (MATH 111) College Algebra 3 cr. Offered autumn and spring. Prereq., M 095 (MAT 100) or appropriate placement score. Intended to strengthen algebra skills. The study of functions and their inverses; polynomial, rational, exponential, and logarithmic functions. Credit not allowed for both M 121 (MATH 111, MAT 118), and M 151 (MATH 121, MAT 120).

U 122 (MATH 112) College Trigonometry 3 cr. Offered autumn and spring. Prereq., M 121 (MATH 111) or appropriate placement score. Preparation for calculus based on college algebra. Review of functions and their inverses, exponential and logarithmic functions. Trigonometric functions and identities, polar coordinates and an optional topic such as conic sections or parametric functions. Credit not allowed for both M 122 (MATH 112, MAT 119) and M 151 (MATH 121, MAT 120).

U 135 (MATH 130) Mathematics for K-8 Teachers I 5 cr. Offered autumn and spring. Prereq., M 095 (MAT 100) or appropriate placement score. Open only to elementary education majors. Topics include problem-solving, sets and logic, functions, whole

numbers, integers, rational numbers, real numbers, number theory, probability and statistics.

U 136 (MATH 131) Mathematics for K-8 Teachers II 4 cr. Offered autumn and spring. Prereq., M 135 (MATH 130). Topics include introductory geometry, geometric constructions, congruence, similarity, measurement, coordinate geometry and an introduction to computer geometry.

U 151 (MATH 121) Precalculus 4 cr. Offered autumn and spring. Prereq., appropriate placement score. A one semester preparation for calculus (as an alternative to M 121-122 (MATH 111–112)). Functions of one real variable are introduced in general and then applied to the usual elementary functions, namely polynomial and rational functions, exponential and logarithmic functions, trigonometric functions, and miscellaneous others. Inverse functions, polar coordinates and trigonometric identities are included. Credit not allowed for both M 151 (MATH 121, MAT 120) and M 121 or 122 (MATH 111 or 112, MAT 118 or 119).

U 162 (MATH 150) Applied Calculus 4 cr. Offered autumn and spring. Prereq., appropriate placement score or one of M 121, 122 or 151 (MATH 111, 112 or 121). Introductory course surveying the principal ideas of differential and integral calculus with emphasis on applications and computer software. Mathematical modeling in discrete and continuous settings. Intended primarily for students who do not plan to take higher calculus.

U 171 (MATH 152) Calculus I 4 cr. Offered autumn and spring. Prereq., M 122 or 151 (MATH 112 or 121) or appropriate placement score. Differential calculus, including limits, continuous functions, Intermediate Value Theorem, tangents, linear approximation, inverse functions, implicit differentiation, extreme values and the Mean Value Theorem. Integral Calculus including antiderivatives, definite integrals, and the Fundamental Theorem of Calculus.

U 172 (MATH 153) Calculus II 4 cr. Offered autumn and spring. Prereq., M 171 (MATH 152). Techniques of Integration. Area computations. Improper integrals. Infinite series and various convergence tests. Power series. Taylor's Formula. Polar coordinates. Parametric curves.

U 181 Honors Calculus I 4 cr. Offered autumn. Prereq., consent of instr. Coreq., Honors Calculus Seminar, a section of M 294 (MATH 294. Honors version of M 171 (MATH 152).

U 182 Honors Calculus II 4 cr. Offered spring. Prereq., M 181 or consent of instr. Coreq., Honors Calculus Seminar, a section of M 294 (MATH 294). Honors version of M 172 (MATH 153).

U 191 (MATH 95) Special Topics Variable cr. (R–6) Offered autumn and spring. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

U 221 Introduction to Linear Algebra 4 cr. Offered autumn and spring. Prereq., M 172 (MATH 153). Vectors in the plane and space, systems of linear equations and Gauss–Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, vector spaces, linear transformations. Calculators and/or computers used where appropriate.

U 225 Introduction to Discrete Mathematics 3 cr. Offered autumn. Prereq., M 162 or 171 (MATH 150 or 152) or consent of instr. Mathematical concepts used in computer

science with an emphasis on mathematical reasoning and proof techniques. Elementary logic, sets, functions and relations, combinatorics, mathematical induction, recursion and algorithms. Mathematics majors should take M 307 instead of 225 (MATH 305 instead of 225).

U 231 Topics in Geometry 3 cr. Offered intermittently. Prereq., M 136 (MATH 131) or consent of instr. Geometry topics for teaching grades 6–12 mathematics. Intended primarily for students in elementary education who plan to teach middle school mathematics.

U 273 (MATH 251) Multivariable Calculus 4 cr. Offered autumn and spring. Prereq., M 172 (MATH 153). Calculus of functions of several variables; differentiation and elementary integration. Vectors in the plane and space.

U 274 (MATH 158) Introduction to Differential Equations 3 cr. Offered spring. Prereq., M 162 (MATH 150) or M 171 (MATH 152) and knowledge of basic trigonometry. Solution of ordinary differential equations and systems with emphasis on applications, numerical methods and computer software.

U 291 (MATH 295) Special Topics Variable cr. (R-9) Offered autumn and spring. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 292 (MATH 296) Independent Study Variable cr. (R-9) Offered autumn and spring. Prereq., consent of instr. Guidance of an individual student in doing independent study on material not offered in a regular course.

U 294 Seminar Variable cr. (R–9) Offered autumn and spring. Prereq., consent of instr.

U 300 Undergraduate Mathematics Seminar 1 cr. (R–6) Offered every semester. Prereq., M 171 (MATH 152). Discussion seminar focused on topics and issues of interest to students in the mathematical sciences.

UG 301 Mathematics Technology for Teachers 3 cr. Offered autumn. Prereq., M 221 (MATH 221). Discrete and continuous mathematical models from a variety of disciplines using appropriate technology.

U 307 (MATH 305) Introduction to Abstract Mathematics 3 cr. Offered autumn and spring. Prereq., M 172 (MATH 153). Designed to prepare students for upper–division proof–based mathematics courses. Topics include proof techniques, logic, sets, relations, functions and axiomatic methods. Students planning to take both M 221 and 307 (MATH 221 and 305) are encouraged to take M 221 (MATH 221) first.

UG 311 Ordinary Differential Equations and Systems 3 cr. Offered autumn. Prereq., M 273 (MATH 251). Ordinary differential equations. Systems of linear differential equations from a matrix viewpoint. Series solutions. Existence and uniqueness for initial value problems. Numerical methods. Stability and selected topics. M 317 (MATH 317) computer lab recommended.

UG 317 Ordinary Differential Equations Computer Lab 1 cr. Offered autumn. Coreq., M 311 (MATH 311) or consent of instr. Intended primarily for student in M 311 (MATH 311).

UG 325 Discrete Mathematics 3 cr. Offered spring. Prereq., M 171 and 225 or 307 (MATH 152 and 225 or 305). Continuation of 225 and topics from graph theory, Boolean algebras, automata theory, coding theory, computability and formal languages.

UG 326 Number Theory 3 cr. Offered spring. Prereq., M 225 or 307 (MATH 225 or 305). Congruences, Diophantine equations, properties of primes, quadratic residues, continued fractions, algebraic numbers.

UG 361 (MATH 381) Discrete Optimization 3 cr. Offered spring. Prereq., M 162 or 172 (MATH 150 or 153) (221 or 225 recommended). Intended for non–mathematics majors as well as mathematics majors. Introduction to discrete optimization and modeling techniques with applications. Topics from combinatorics and graph theory, including enumeration, graph algorithms, matching problems and networks.

UG 362 (MATH 382) Linear Optimization 3 cr. Offered autumn. Prereq., M 162 or 172 (MATH 150 or 153) (221 recommended). Coreq., M 363 (MATH 388) recommended. Intended for non–mathematics majors as well as majors. Introduction to linear programming and modeling techniques with applications. Topics include the simplex method, duality, sensitivity analysis and network models.

UG 363 (MATH 388) Linear Optimization Laboratory 1 cr. Offered autumn. Coreq., M 362 (MATH 382). Introduction to linear optimization software.

UG 381 (MATH 351) Advanced Calculus I 4 cr. Offered autumn even-numbered years. Prereq., M 273, 307 (MATH 251, 305). Rigorous development of the theory of functions of several variables. Differentiability, Taylor's theorem, inverse and implicit function theorems, multiple integration, differential forms and Stokes' theorem.

U 390 Supervised Internship 1–9 cr. (R–9) Prereq., consent of dept.

U 391 (MATH 395) Special Topics Variable cr. (R-9) Offered autumn and spring. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 392 (MATH 396) Independent Study Variable cr. (R-9) Offered autumn and spring. Prereq., consent of instr. Guidance of an individual student in doing independent study on material not offered in a regular course.

U 394 Seminar Variable cr. (R–9) Offered autumn and spring. Prereq., consent of instr.

U 398 Internship Variable cr. Offered autumn and spring. Prereq., consent of instructor. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

UG 412 Partial Differential Equations 3 cr. Offered spring. Prereq., M 311 (MATH 311). Fourier series, Sturm–Liouville and boundary value problems. Partial differential equations: Cauchy problems and the method of characteristics, separation of variables and Laplace transform methods. Numerical methods and selected topics. M 418 (MATH 418) computer lab recommended.

UG 414 Deterministic Models 3 cr. Offered autumn. Prereq., M 274 or 311 (MATH 158 or 311) or consent of instr. Linear and nonlinear difference and differential equations: stability, phase–plane analysis, oscillatory behavior, limit cycles, and chaos. Eigenvalues and eigenfunctions. Emphasis on models in biology.

UG 418 Partial Differential Equations Computer Lab 1 cr. Offered spring. Coreq., M 412 (MATH 412) or consent of instr. Intended primarily for students in M 412 (MATH 412).

UG 429 (MATH 406) History of Mathematics 3 cr. Offered spring. Prereq., M307 (MATH 305). Historical study of the development of mathematics from the Egyptian and Babylonian eras to the 20th century.

UG 431 (MATH 421) Abstract Algebra I 4 cr. Offered autumn. Prereq., M 221 and 307 (MATH 221 and 305) or consent of instr. An introduction to modern ideas of algebra through the study of groups, rings, and fields.

UG 432 (MATH 422) Abstract Algebra II 4 cr. Offered spring. Prereq., M 431 (MATH 421). Continues the investigation of groups, rings, and fields begun in M 431 (MATH 421). Further topics include vector spaces and field extensions.

UG 439 (MATH 431) Euclidean and Non–Euclidean Geometry 3 cr. Offered autumn. Prereq., M 307 (MATH 305); M 231 (MATH 231) recommended. Euclidean geometry from a rigorous, axiomatic viewpoint and Non–Euclidean geometries chosen from Lobachevskian, projective, finite and Riemannian.

UG 440 (MATH 471) Numerical Analysis 4 cr. Offered intermittently. Prereq., M 307, 311 (MATH 305, 311), one computer language. Error analysis; approximation and interpolation, numerical solution of linear and non-linear equations, numerical integration of ordinary and partial differential equations.

UG 445 (MATH 475) Statistical, Dynamical, and Computational Modeling 4 cr. Offered autumn odd-numbered years. Prereq., consent of instr. An interdisciplinary course on the integration of statistical and dynamical models with applications to biological problems. Linear and nonlinear models, estimation, systems of ordinary differential equations, numerical integration, bootstrapping, MCMC methods. Intended both for students in mathematics and the natural sciences.

UG 472 (MATH 452) Introduction to Complex Analysis 4 cr. Offered spring. Prereq., M 273 (MATH 251), M 307 (MATH 305). Analytic functions, complex integration, singularities and application to contour integration, harmonic functions, spaces of analytic functions.

UG 473 (MATH 451) Introduction to Real Analysis 4 cr. Offered autumn odd-numbered years. Prereq., M 273 (MATH 251), M 307 (MATH 305). Theory of metric spaces and point set topology, Riemann-Stieltjes integral, sequences and series of functions. Stone-Weierstrass theorem, theorem of Arzela-Ascoli, introduction to Lebesgue integration.

UG 485 Graph Theory 3 cr. Offered autumn. Prereq., M 325, or M 307 and M 361 (MATH 325, or MATH 305 and 381), or consent of instr. Theory and applications of graphs. Topics chosen from trees, matchings, connectivity, coloring, planarity, Ramsey theory, random graphs, combinatorial designs and matroid theory.

UG 491 (MATH 495) Special Topics Variable cr. (R–9) Offered autumn and spring. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

U 492 (MATH 496) Independent Study Variable cr. (R–9) Offered autumn and spring. Prereq., consent of instr. Guidance of an individual student in doing independent study on material not offered in a regular course

U 494 Seminar Variable cr. (R-9) Offered autumn and spring. Prereq., consent of instr.

U 498 Internship Variable cr. Offered autumn and spring. Prereq., consent of instr. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the

faculty supervisor and the Internship Services office. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

U 499 Senior Thesis Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr. Senior thesis for mathematics majors and/or Watkins Scholars.

G 500 Current Mathematical Curricula 3 cr. Offered intermittently. Prereq., undergraduate major or minor in mathematics. Analysis of contemporary materials for secondary school mathematics: the goals, the mathematical content, alternative methodologies, and curriculum evaluation.

G 501 Technology in Mathematics for Teachers 3 cr. Offered intermittently. Prereq., undergraduate mathematics major or minor. Technology usage—when it is appropriate and when it is not. Experience is provided with scientific calculators, graphing utilities, computers, and identification of exemplary software.

G 504 Topics in Math Education Variable cr. (R–12) Offered intermittently. Prereq., teacher certification. Topics of current interest which may include calculus, number theory, probability and statistics, geometry, or algebra, at a level suitable for teachers.

G 510 Problem Solving for Teachers 3 cr. Offered intermittently in summer. Prereq., undergraduate major or minor in mathematics. Strategies for problem solving, problem posing in a variety of situations, modeling and applications. Problems are selected from various areas of mathematics.

G 511 Advanced Mathematical Methods I 3 cr. Offered autumn odd–numbered years. Prereq., M 311, and 412 or 414 (MATH 311, and 412 or 414). Methods in applied mathematics related to the qualitative and quantitative solution of nonlinear and differential integral equations, dynamical systems, and perturbation methods. Applications of these methods to other sciences.

G 512 Advanced Mathematical Methods II 3 cr. Offered spring even–numbered years. Prereq., M 511 (MATH 511). Continuation of M 511 (MATH 511).

G 514 Topics in Applied Mathematics Variable cr. (R–12) Offered autumn even–numbered years. Prereq., consent of instr. or M 511-512 (Math 511–512). Topics of current interest in applied mathematics, mathematical modeling, dynamic modeling, and optimal management in stochastic or deterministic environments.

G 520 Algebra for Teachers 3 cr. Offered intermittently in summer. Prereq., M 431 (MATH 421) or equiv. Topics include algebraic number fields, linear algebra topics, and applications appropriate for secondary teachers.

G 521 Advanced Algebra I 3 cr. Offered alternate years. Prereq., M 432 (MATH 422) or consent of instr. Topics covered include group theory, field theory and Galois theory.

G 522 Advanced Algebra II 3 cr. Offered alternate years. Prereq., M 521 (MATH 521) or consent of instr. Continuation of 521; rings, modules, commutative algebra, and further topics.

G 524 Topics in Algebra I 3 cr. (R-6) Offered alternate years. Prereq., M 432 (MATH 422) or consent of instr. Topics have included algebraic geometry, commutative ring theory and advanced linear algebra.

G 525 Topics in Algebra II 3 cr. (R-6) Offered alternate years. prereq., M 524 (MATH 524) or consent of instr. Continuation of M 524 (MATH 524).

G 526 Discrete Mathematics for Teachers 3 cr. Offered intermittently in summer. Prereq., M 307 (MATH 305) or consent of instr. Elements and operations of finite

structures, combinatorics, recursion, graph theory, matrix representations, and finite state transition models.

G 530 Geometries for Teachers 3 cr. Offered intermittently in summer. Prereq., M 439 (MATH 431) or equiv. Comparison of synthetic, analytic, vector, and transformational approaches to geometry. Includes classification of geometries, geometric representations, axiomatics, and the applications of modern geometries.

G 531 Topology 3 cr. Offered autumn even–numbered years. Prereq., M 473 (MATH 451) or consent of instr. Set theory, topological spaces, metrizability, continuous mappings and selected topics.

G 532 Algebraic Topology 3 cr. Offered spring alternate years. Prereq., M 431 (MATH 421) and M 531 (MATH 531) or consent of instr. Introduction to algebraic topology through one or more topics chosen from the fundamental group and higher homotopy groups, singular homology, and simplicial homology.

G 550 Analysis for Teachers 3 cr. Offered intermittently in summer. Prereq., M 273 (MATH 251) or equiv. Notions of limits, continuity, differentiation, and integration in R^n.

G 551 Real Analysis 3 cr. Offered spring even–numbered years. Prereq., M 473 or 472 (MATH 451 or 452) or consent of instr. Measure theory, abstract integration theory, theory of Lp–spaces.

G 555 Functional Analysis 3 cr. Offered spring odd–numbered years. Prereq., M 473 or 472 (MATH 451 or 452) or consent of instr. Normed linear spaces, linear functionals, separation theorems, topological linear spaces, weak topologies, dualities.

G 564 Topics in Analysis 3 cr. (R–12) Offered autumn odd–numbered years. Prereq., consent of instr. Research projects or topics in analysis. May include but not restricted to Banach algebras, Fourier analysis, Harmonic analysis, Hilbert space theory, integral equations, or operator theory.

G 581 Combinatorics 3 cr. Offered autumn odd–numbered years. Prereq., consent of instr. Theory and applications of discrete mathematics. Topics chosen from enumeration, combinatorial analysis, and graph theory.

G 582 Optimization 3 cr. Offered autumn even–numbered years. Prereq., consent of instr. Theory and applications of optimization. Topics chosen from linear, non–linear, and discrete optimization, including duality theory, convexity and networks.

G 584 Topics in Combinatorics and Optimization 3 cr. (R–12) Offered spring odd–numbered years. Prereq., consent of instr. Topics chosen from the areas of combinatorics and optimization. May include classical problems, current trends, research interests or other topics chosen by the instructor.

G 593 Professional Project Variable cr. (R–6) Offered autumn and spring. Prereq., consent of advisor.

G 595 Special Topics Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

G 596 Independent Study Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 597 Research Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 598 Internship Variable cr. (R–12) Offered autumn and spring. Prereq., consent of department. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office.

G 599 Thesis Variable cr. (R–6) Offered autumn and spring. Prereq., consent of instr.

G 600 Mathematics Colloquium 1 cr. (R–3) Offered autumn and spring. Prereq., consent of advisor.

G 602 Teaching College Mathematics 3 cr. Prereq., second year standing in graduate school. Topics include publishing, grant writing, writing in mathematics classes, media use in mathematics, evaluation and assessment of curricular materials and programs, instructional methods in university mathematics courses, and other selected topics.

G 605 Learning Theories in Mathematics 3 cr. Prereq., graduate status. How children learn mathematical content and processes. Models of mental development, concept formation, problem solving, reasoning, and creative thinking.

G 606 Current Topics in the History of Mathematics 3 cr. Examination of mathematical history topics from the latter part of the 20th century. Discussions may focus on the impact of Hilbert's Problems. Research on current mathematics.

G 610 Graduate Seminar in Applied Mathematics Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 620 Graduate Seminar in Algebra Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 630 Graduate Seminar in Geometry/Topology Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 650 Graduate Seminar in Analysis Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 670 Graduate Seminar in Numerical Analysis Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 680 Graduate Seminar in Combinatorics and Optimization Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 690 Supervised Internship Variable cr. (R–6) Offered autumn and spring. Prereq., consent of department. Supervised Teaching Internship.

G 691 Research Methods in Mathematics Education 3 cr. Prereq., consent of instr. Resources for learning of reported research, critical reviews of research, quantitative and qualitative processes.

G 694 Seminar Variable cr. (R–12) Offered autumn and spring. Prereq., consent of instr.

G 699 Dissertation Variable cr. (R–9) Offered autumn and spring.

Statistics (STAT)

U 216 (MATH 241) Introduction to Statistics 4 cr. Offered autumn and spring. Prereq., M 115 (MATH 117) or consent of instr. Introduction to major ideas of statistical inference. Emphasis is on statistical reasoning and uses of statistics.

UG 341 (MATH 341) Introduction to Probability and Statistics 3 cr. Offered autumn and spring. Prereq., M 162 or 172 (MATH 150 or 153). Probability, probability models and simulation, random variables, density functions, special distributions, and a brief survey of estimation and hypothesis testing. Computer use integrated throughout.

UG 421 (MATH 441) Probability Theory 3 cr. Offered autumn. Prereq., M 273 (MATH 251) and STAT 341 (MATH 341) or consent of instr. An introduction to probability, random variables and their probability distributions, estimation and hypothesis testing. This course is the foundation on which more advanced statistics courses build.

UG 422 (MATH 442) Mathematical Statistics 3 cr. Offered spring. Prereq., STAT 421 (MATH 441). Continuation of 421.

UG 451 (MATH 444) Statistical Methods I 3 cr. Offered autumn. Prereq., one year of college mathematics including M 115 (MATH 117) or equiv. course in probability or consent of instr. May not be counted toward a major in mathematics. Intended primarily for non-mathematics majors who will be analyzing data. Graphical and numerical summaries of data, elementary sampling, designing experiments, probability as a model for random phenomena and as a tool for making statistical inferences, random variables, basic ideas of inference and hypothesis testing.

UG 452 (MATH 445) Statistical Methods II 3 cr. Offered spring. Prereq., STAT 451 (MATH 444). Continuation of STAT 451 (MATH 444). May not be counted toward a major in mathematics. Multiple regression, experimental design, analysis of variance, other statistical models.

UG 457 (MATH 447) Computer Data Analysis I 1 cr. Offered autumn. Coreq., STAT 451 (MATH 444) or consent of instr. An introduction to software for doing statistical analyses. Intended primarily for students in STAT 451 (MATH 444).

UG 458 (MATH 448) Computer Data Analysis II 1 cr. Offered spring. Coreq., STAT 452 (MATH 445) or consent of instr. Continuation of STAT 457 (MATH 447). Intended primarily for students in STAT 452 (MATH 445).

G 540 (MATH 540) Probability and Statistics for Teachers 3 cr. Offered intermittently in summer. Prereq., STAT 341 (MATH 341) or equiv. A survey of modern topics in probability and statistics. Emphasis will be on applications of statistics in real situations.

G 541 (MATH 541) Advanced Mathematical Statistics 3 cr. Offered intermittently. Prereq., STAT 422 (MATH 442). Advanced theory of estimation and hypothesis testing including large sample theory.

G 542 (MATH 542) Applied Linear Models 3 cr. Offered autumn even-numbered years. Prereq., STAT 422 (MATH 442) or consent of instr. Numerical and graphical data summaries, simple linear and multiple regression and analysis of variance, including estimation, hypothesis testing, residual analysis, diagnostics, and model-building strategies. Use of the computer and real data sets integrated throughout.

G 543 (MATH 543) Applied Multivariate Statistical Analysis 4 cr. Offered spring even-numbered years. Prereq., STAT 452 or 422 (MATH 445 or MATH 442), or consent of instr. Introduction to multivariate statistical methods and applications. Includes appropriate linear algebra, random vectors, multivariate normal distribution, multivariate ANOVA, principal components, clustering, discriminant analysis, and related topics. Use of the computer and real data sets integrated throughout. Intended for students in mathematics and in other fields.

G 544 (MATH 544) Topics in Probability and Statistics 3 cr. (R-12) Offered intermittently. Prereq., STAT 422 (MATH 442) and consent of instr. May include theory of nonparametric statistics, generalized linear models, stochastic processes or other topics chosen by the instructor.

G 545 (MATH 545) Theory of Linear Models 3 cr. Offered autumn odd-numbered years. Prereq., STAT 422 (MATH 442). Multivariate normal distribution, distribution of quadratic forms, estimation and hypothesis testing in the full rank and less than full rank general linear models.

G 547 (MATH 547) Applied Nonparametric Statistics 3 cr. Offered autumn odd-numbered years. Prereq., STAT 421 or 452 (MATH 441 or 445) or consent of instr. Statistical estimation and inference based on ranks and elementary counting methods. Applications to a variety of situations including one- and two-sample, correlation, regression, analysis of variance, and goodness-of-fit problems. Use of the computer and real data sets integrated throughout. Intended for students in mathematics and in other fields.

G 549 (MATH 549) Applied Sampling 3 cr. Offered autumn even-numbered years. Theory and application of methods for selecting samples from populations in order to efficiently estimate parameters of interest. Includes simple random, systematic, cluster, stratified, multistage, line transect, distance and adaptive sampling. Use of the computer and real data sets integrated throughout. Intended for students in mathematics and in other fields.

G 640 (MATH 640) Graduate Seminar in Probability and Statistics Variable cr. (R-12) Offered autumn and spring. Prereq., consent of instr.

Faculty

Professors

Richard W. Billstein, Ed.D., The University of Montana, 1972

Jonathan Graham, Ph.D., North Carolina State University, 1995

James J. Hirstein, Ed.D., University of Georgia, 1976

Leonid Kalachev, Ph.D., Moscow State University, 1987 (Chair)

P. Mark Kayll, Ph.D., Rutgers University, 1994

Jennifer McNulty, Ph.D., University of North Carolina at Chapel Hill, 1993

D. George McRae, Ph.D., University of Washington, 1967

David A. Patterson, Ph.D., University of Iowa, 1984

Bharath Sriraman, Ph.D., Northern Illinois University, 2002

Emily Stone, Ph.D., Cornell University, 1989

Karel M. Stroethoff, Ph.D., Michigan State University, 1987

Thomas Tonev, Ph.D., Moscow State University, 1973

Nikolaus Vonessen, Ph.D., Massachusetts Institute of Technology, 1988

Associate Professors

John Bardsley, Ph.D., Montana State University, 2002
Jennifer Halfpap, Ph.D., University of Wisconsin, 2005
Solomon Harrar, Ph.D., Bowling Green State University, 2004
Greg St. George, Ph.D., The University of Montana, 1989
Brian Steele, Ph.D., The University of Montana, 1995

Assistant Professors

Eric Chesebro, Ph.D., University of Texas at Austin, 2006
Ke Wu Norman, Ph.D., University of Minnesota, 2008
Kelly McKinnie, Ph.D., University of Texas at Austin, 2006

Lecturers

Lauren Fern, M.S., Northern Illinois University, 1994
Cindy Leary, M.A., The University of Montana, 2006
Regina Souza, Ph.D., Massachusetts Institute of Technology, 1990

Emeritus Professors

William R. Ballard, Ph.D., University of Chicago, 1957
Charles A. Bryan, Ph.D., University of Arizona, 1963
William R. Derrick, Ph.D., Indiana University, 1966
Rudy A. Gideon, Ph.D., University of Wisconsin, 1970
Stanley I. Grossman, Ph.D., Brown University, 1969
Gloria C. Hewitt, Ph.D., University of Washington, 1962
Don O. Loftsgaarden, Ph.D., Montana State University, 1964
Johnny W. Lott, Ph.D., Georgia State University, 1973
Robert W. McKelvey, Ph.D., University of Wisconsin 1954
William M. Myers, Jr., Ph.D., Ohio State University, 1952
Howard E. Reinhardt, Ph.D., University of Michigan, 1959
George F. Votruba, Ph.D., University of Michigan, 1964
I. Keith Yale, Ph.D., University of California, Berkeley, 1966