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College of Letters and Science • Catalog, Part

Announcement of Courses, 1964-66

This is part one of the catalog of The University of Wisconsin at Madison. The first section, "Information for Prospective Students," gives details of applying for admission, fees and tuition, living costs, student financial aids, housing, student life, and degrees.

It is also the College of Letters and Science Bulletin, with requirements and offerings listed in detail. Part two of the catalog contains reprints of the bulletins of other colleges and schools, and is intended for reference use by counseling offices, libraries, and other educational institutions.

For a list of bulletins available to prospective students, or for information on correspondence courses, Summer Sessions, graduate study, Milwaukee campus, and University Centers, turn to "Where to Write."

The Bulletin of The University of Wisconsin is published 15 times annually—once in March, April, July, August, September, October, and November; and twice in January, February, May, and June. Second-class postage is paid at Madison, Wisconsin.

Volume 1965, Number 15 • Madison, Wisconsin • November, 1965

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242. (39a) European Drama and Theatre: The Age of Enlightenment and the Romantic Revolt. II; 3 cr. A continuation of Speech 241 (39), but may be taken as an independent unit; drama and theatre practice in France, Germany, Italy, and Scandinavia from 1700 to 1850. Prereq: So st. Staff.

243. (67a) Continental Drama—Ibsen and His Contemporaries. I; 3 cr. A study of the development of modern realistic drama, its nature, trends and impact, through the plays of Buchner, Ibsen, Zola, Strindberg, Chekhov, Hauptmann, and others (in translation). Prereq: So st. Mr. Manfull.

244. (67b) Continental Drama—The Twentieth Century. II; 3 cr. The development of realism and expressionism in the plays and dramatic theory of Strindberg, Wedekind, Pirandello, Anouilh, Nietzsche, Ionesco, and Brecht (in translation). Prereq: So st. Mr. Manfull.

Mathematics

Professors Buck, *Chairman*, Bing, Bruck, Fadell, Hammer, Ingraham, Johnson, Kleene, Langer, Mann, Meyer, Noble, Nohel, Rosser, W. Rudin, K. Smith, Van Engen, Wasow, Wilcox, Young; Associate Professors Beck, Bicknell, Brauer, *Associate Chairman*, Chover, Keisler, Knopp, Levin, Osborn, Parter, Schneider, M. Smith; Assistant Professors Askey, Bauman, Bean, Bleicher, Coleman, Conley, Conner, Crowe, Edwards, Feldzamen, Forelli, Giles, Hellerstein, Holland, Husseini, Kosier, Levy, Martin, McQuillan, Miles, Morley, Ohm, Roy, Ryan, Sandomierski, Smart, Turner, Voichick, Willoughby; Lecturers Evans, M. E. Rudin.

Mathematics is classified both with the humanities and the sciences. Its position among the humanities is based on the study of mathematics as one of the liberal arts for more than 2,000 years. Far from becoming stagnant, mathematics offers more new and challenging frontiers than at any time in its long history—with totally new fields, requiring new techniques and ideas for exploration.

The place of mathematics among the sciences is well founded. The natural sciences have invariably turned to mathematics for the techniques needed to explore the consequences of scientific theories. Economists, psychologists, and engineers find higher mathematics of value in their training and research.

Career opportunities abound in mathematics. Teaching, both at the secondary and college level, remains a stimulating and attractive goal. The growing field of mathematical engineering has much to offer the student. For those interested in Applied Mathematics and Engineering Physics, see page 91. With additional graduate training, a student may prepare himself for a career in research in universities, industry, or government. For those interested in commerce, actuarial mathematics, used in the insurance field, offers employment opportunities with government agencies, insurance companies, or consulting firms.

Departments offering related courses are computer sciences and statistics.

Pre

Four levels of preuniversity m
below. Prospective science stude
matical preparation before comin
enroll in Mathematics 231 (20) o
man year.

1. *Minimum mathematical prep*
and algebra: an understanding o
the decimal system and its use in
properties of rational numbers; a
setting up and solving linear eq
integral exponents. From geomet
theorems concerning straight line
linear equations; the solution of
their geometrical interpretation; f
of spheres, cylinders, and cones.

This level of preparation will a
and fields of specialization in the
a prerequisite for Mathematics 10

2. *Intermediate mathematical*
together with: solution and appli
equalities, complex numbers, ratio
graphing of circles and quadratic
properties of logarithms, use of t
such as the slide rule for numeri

A student normally can achiev
tion in two and one-half to three
prerequisite for Mathematics 106

3. *Advanced mathematical prep*
gether with: mathematical induct
of polynomials and rational func
orems for polynomials; function
geometry and/or analytic geomet
including graphs and equations
other geometric figures in two a
of systems of linear equations,
(based on arc length) and graph
of right triangles, laws of sines
addition formulas and other iden
tions, and solution of trigonometr

A student normally can achiev
in three to four years. This leve
Mathematics 231 (20), 107 (7), a
the first course in mathematics
Engineering.]

drama, its nature, trends and impact, through the plays of Buchner, Ibsen, Zola, Strindberg, Chekhov, Hauptmann, and others (in translation). Prereq: So st. Mr. Manfull.

244. (67b) Continental Drama—The Twentieth Century. II; 3 cr. The development of realism and expressionism in the plays and dramatic theory of Strindberg, Wedekind, Pirandello, Anouilh, Nietzsche, Ionesco, and Brecht (in translation). Prereq: So st. Mr. Manfull.

BRUCK, FADELL, HAMMER, INGRAHAM, MEYER, NOBLE, NOHEL, ROSSER, W. SOW, WILCOX, YOUNG; Associate Pro- *sociate Chairman,* CHOVER, KEISLER, CHNEIDER, M. SMITH; Assistant Pro- ICHER, COLEMAN, CONLEY, CONNER, ELLI, GILES, HELLERSTEIN, HOLLAND, McQUILLAN, MILES, MORLEY, OHM, URNER, VOICHICK, WILLOUGHBY; Lec-

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nathematics. Teaching, both at the s a stimulating and attractive goal. engineering has much to offer the plied Mathematics and Engineering al graduate training, a student may search in universities, industry, or commerce, actuarial mathematics, mployment opportunities with govnies, or consulting firms.

urses are computer sciences and

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Prerequisites for Beginning Courses

Four levels of preuniversity mathematical competence are specified below. Prospective science students should achieve *advanced mathematical preparation* before coming to the University, so that they may enroll in Mathematics 231 (20) or 221 (60) at the start of their freshman year.

1. *Minimum mathematical preparation* (two years). From arithmetic and algebra: an understanding of the axioms that underlie arithmetic; the decimal system and its use in calculation; definition and elementary properties of rational numbers; arithmetic progressions; experience in setting up and solving linear equations and inequalities; and positive integral exponents. From geometry: axioms, theorems, and proofs of theorems concerning straight lines, triangles, and circles; graphing of linear equations; the solution of systems of two linear equations and their geometrical interpretation; formulas for volumes and surface areas of spheres, cylinders, and cones.

This level of preparation will allow a student to enroll in all majors, and fields of specialization in the College of Letters and Science. It is a prerequisite for Mathematics 101 (1).

2. *Intermediate mathematical preparation.* The topics listed above, together with: solution and applications of quadratic equations and inequalities, complex numbers, rational exponents, geometric progressions, graphing of circles and quadratic polynomials; definition and elementary properties of logarithms, use of tables of logarithms and other devices such as the slide rule for numerical computation.

A student normally can achieve intermediate mathematical preparation in two and one-half to three years. The level of preparation is a prerequisite for Mathematics 106 (6), and for Mathematics 240 (31).

3. *Advanced mathematical preparation.* The topics listed above, together with: mathematical induction, the binomial theorem, the algebra of polynomials and rational functions, the remainder and factor theorems for polynomials; functions; further selected topics in solid geometry and/or analytic geometry, preferably analytic geometry and including graphs and equations of lines, planes, circles, spheres, and other geometric figures in two and three dimensions: a deeper study of systems of linear equations, including determinants; definitions (based on arc length) and graphs of trigonometric functions, solution of right triangles, laws of sines and cosines for oblique triangles, the addition formulas and other identities relating the trigonometric functions, and solution of trigonometric equations.

A student normally can achieve advanced mathematical preparation in three to four years. This level of preparation is a prerequisite for Mathematics 231 (20), 107 (7), and 221 (60). [Mathematics 221 (60) is the first course in mathematics which carries credit in the College of Engineering.]

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4. *Superior mathematical preparation.* Some high schools may offer topics to students with advanced mathematical preparation; for example, courses in probability and statistics, calculus (with the necessary analytic geometry) and/or topics in modern algebra are suitable for high-school students of superior ability. Students who have completed a program of study beyond advanced mathematical preparation will be placed at the University on an individual basis, by consultation between the Department of Mathematics and the student, upon recommendation of his high school.

High-School Certification and College Placement Tests

Each entering freshman should have his level of mathematical preparation certified by his high school before his registration at the University.

In addition to his certification, each entering freshman who intends to take mathematics courses in the University is required to take the Placement Examination in Mathematics at or before the time of registration. The student should review high-school mathematics, particularly algebra and trigonometry, prior to the examination.

Major

M

To be accepted as a major in mathematics, a student must complete Mathematics 231 (20), 232 (21), and 233 (22) (or an equivalent sequence of calculus and analytic geometry) with a grade-point average of 2.5 or better. A prospective major will ordinarily take a year's course in physics during his sophomore year, preferably Physics 207-208 (31a-b).

Required in addition are a minimum of 17 credits selected from mathematics courses numbered above 301-302 (101 a-b), which must include 3 credits in algebra, 3 credits in analysis, 3 credits in geometry, and 2 or 3 credits in Mathematics 671 (150). All students with the exception of those majoring jointly in mathematics and education are required to take at least one connected year course in one of the following: algebra, analysis, geometry (which may include topology), applied mathematics, probability and statistics, numerical analysis.

Students who elect a joint major in mathematics and education must take a minimum of 14 credits above Mathematics 301-302 (101 a-b).

Students who plan to take graduate work in mathematics should take a year course in algebra and complete a year of advanced calculus. They also should acquire a reading knowledge of two or more foreign languages as early as possible. For mathematics, the important languages are Russian, German, French, and Italian.

Mathematics Honors Courses

Honors credit is offered in the honors sections of Mathematics 221 (60), 231 (20), 232 (21), 233 (22).

To earn the B.A. or B.S. with l
complete the following: (a) the ge
the college, (b) the requirements
described on page 54, and (c) the
the department.

Junior-senior honors curriculum:
the following advanced courses: 41
(109), 521 (120a), 522 (120b), 541
(119), 563 (122), 565 (123), 567 (16
(125). In addition, any graduate cou
carry honors credit. Occasionally ot
if the student obtains permission fro
the course instructor, and the chairm
Honors majors must complete the y
522 (120b), and 541 (115a) and 54
gether with at least a one-semester
equivalent). They must in the seni
(100b), each 3 credits, Senior honors

Students majoring in mathematics
earn honors in the major by satisfac
listed above for honors candidates m

6

There are two sequences of courses in
matics 231 (20), 232 (21), and 233 (22) en
usually taken by letters and science student
223 (62) are intended primarily for science
essentially the same material as 231 (20), 23
on physical applications.

101. (1) **Introductory College Algebra.** I, II; 0-4 cr. Development of the number system and the fundamental operations of algebra, linear and quadratic equations, exponents and logarithms, variations, progressions, the binomial theorem; does not carry credit for students of engineering or for students who have had three years or more of high-school mathematics. Prereq: Minimum mathematical preparation and a satisfactory score on the placement examination.

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L&S General Honors Program

To earn the B.A. or B.S. with honors, majors in mathematics must complete the following: (a) the general course degree requirements of the college, (b) the requirements of the General Honors Program as described on page 54, and (c) the junior-senior honors curriculum in the department.

Junior-senior honors curriculum: Honors credit will be offered in the following advanced courses: 417 (112), 431 (118a), 432 (118b), 463 (109), 521 (120a), 522 (120b), 541 (115a), 542 (115b), 551 (121), 561 (119), 563 (122), 565 (123), 567 (166a), 568 (166b), 623 (116), and 629 (125). In addition, any graduate course taken by an undergraduate will carry honors credit. Occasionally other courses can carry honors credit, if the student obtains permission from the departmental honors adviser, the course instructor, and the chairman of the General Honors Program. Honors majors must complete the year honors courses 521 (120a) and 522 (120b), and 541 (115a) and 542 (115b) (or their equivalents), together with at least a one-semester honors course in geometry (or its equivalent). They must in the senior year take 681 (100a) and 682 (100b), each 3 credits, Senior honors thesis.

Honors in the Major

Students majoring in mathematics who are not honors candidates may earn honors in the major by satisfactorily completing the requirements listed above for honors candidates majoring in mathematics.

600 (Curricular Area Number)

Elementary Courses

There are two sequences of courses in calculus and analytic geometry. Mathematics 231 (20), 232 (21), and 233 (22) emphasize the theoretical aspects and are usually taken by letters and science students. Mathematics 221 (60), 222 (61), and 223 (62) are intended primarily for science and engineering students. They cover essentially the same material as 231 (20), 232 (21), and 233 (22), but with emphasis on physical applications.

101. (1) Introductory College Algebra. I, II; 0-4 cr. Development of the number system and the fundamental operations of algebra, linear and quadratic equations, exponents and logarithms, variations, progressions, the binomial theorem; does not carry credit for students of engineering or for students who have had three years or more of high-school mathematics. Prereq: Minimum mathematical preparation and a satisfactory score on the placement examination.

106. (6) Basic Algebra and Trigonometry. I, II; 0-4 cr. Number systems and equations; plane trigonometry; inequalities; functions and graphs; complex numbers; theory of equations; mathematical induction; the binomial theorem; does not carry credit for students of engineering and students who have had trigonometry in high school. Prereq: Intermediate mathematical preparation and a satisfactory score on the placement examination; or Math. 101 (1).

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107. (7) Introductory Mathematics of Finance and Probability. I, II; 4 cr. Mathematical characteristics of currently used financial growth laws, annuities, amortization, sinking funds, and bonds, the algebra of sets, elementary logic and probability, Bayes theorem, independence of events. Prereq: Completion of Math. 106 (6) or equiv; or advanced mathematics preparation and a satisfactory score on the placement examination.

109. (9) Mathematics for Elementary Teachers. I, II; 3 or 4 cr. Development of the number system with emphasis on real numbers, and the fundamental operations of algebra; approximate computation; introduction to logarithms and use of tables; graphs; elementary applications from business mathematics and statistics; other topics from college algebra, trigonometry, and analytic geometry of special value for teachers of arithmetic. Prereq: One unit each of high-school algebra and geometry; and registration in the Program for the Preparation of Elementary School Teachers.

110. (30) Elementary Statistical Analysis. [See Stat. 110 (30).] Sem; 3 cr. Elements of probability theory; collection and presentation of sample data; basic problems of statistical inference; applications, including quality control; regression; elements of statistical design. Prereq: Math. 231 (20) or 221 (60); or equiv.

201. (24) Theory of Life Insurance. I, II; 3 cr. Introduction to the mathematics of life insurance; mortality tables, net premiums, reserves, nonforfeiture benefits, gross premiums. Prereq: Two courses in mathematics.

221. (60) Calculus and Analytic Geometry. I, II; 5 cr. Introduction to differential and integral calculus and plane analytic geometry, selected topics in advanced algebra and analytic trigonometry reviewed as needed. Prereq: Advanced mathematical preparation and a satisfactory score on the placement examination; or Math. 106 (6).

222. (61) Calculus and Analytic Geometry. I, II; 5 cr. Topics in analytic geometry and linear algebra, transcendental functions, techniques of integration. Prereq: Math. 221 (60).

223. (62) Calculus and Analytic Geometry. I, II; 5 cr. Solid analytic geometry; partial derivatives; multiple integrals; infinite series, introduction to differential equations, and/or other topics in analysis. Prereq: Math. 222 (61).

231. (20) Calculus and Analytic Geometry. I, II; 4 cr. Analytic geometry of the straight line, circle, and conics; polynomials and their graphs; elements of the differential calculus, with applications involving polynomials. Prereq: Advanced mathematical preparation and a satisfactory score on the placement examination; or Math. 106 (6).

232. (21) Calculus and Analytic Geometry. I, II; 4 cr. Differential and integral calculus of algebraic and transcendental functions with applications to the physical and social sciences, further topics in analytic geometry. Prereq: Math. 231 (20).

233. (22) Calculus and Analytic Geometry. I, II; 4 cr. Infinite series, including Taylor's series; solid analytic geometry; partial derivatives; multiple integrals. Prereq: Math. 232 (21).

240. (31) Introductory Finite Mathematics. I, II; 4 cr. Elements of mathematical logic; structure in sets, partitions, and counting; probability theory; stochastic processes. Prereq: Intermediate mathematical preparation.

301. (101a) Calculus. I, II; 4 cr. Functions, limits, and derivatives; differentiation of algebraic function; differentials; integrals, differentiation of transcendental functions; applications; intended only for students transferring from other institutions. Prereq: Course in analytic geometry.

302. (101b) Calculus. I, II; 4 cr. Techniques of integration, partial derivatives, multiple integrals with applications to physics, infinite series. Prereq: Math. 301 (101a).

306. (117) Vector Analysis. Sem; 3 cr. The algebra and calculus of vectors with applications to analysis, geometry, and physics. Prereq: Math. 233 (22) or 223 (62).

307. (104) Theoretical Mechanics. Yr 3 cr.

309. (137a) Introduction to Mathematical Statistics. [See Stat. 309 (137a).] I; 3 or 4 cr. Philosophy of the experimental method; distribution, univariate and multivariate; moments, expected values, variances; normal distribution and derived distributions, estimation, method of least squares. Prereq: Math. 233 (22), 302 (101b), 223 (62), or equiv.

310. (137b) Introduction to Mathematical Statistics. [See Stat. 310 (137b).] II; 3 or 4 cr. Analysis of variances; orthogonal polynomials; multifactor experimental designs, randomized blocks, factorial designs, composite designs; estimation of response relationships. Prereq: Math. 309 (137a).

313. (138) Actuarial Mathematics. Sem; 3 cr. Problems in finite differences, probability, and statistics with particular emphasis on applications to life insurance. Prereq: Math. 233 (22) or 223 (62).

321. (113a) Applied Mathematical Analysis. I; 3 cr. Selected topics in advanced calculus, mainly vector analysis, line and surface and integrals, Jacobians and physical applications. Prereq: Math. 419 (new; replacing old 111), 417 (112), or equiv.

322. (113b) Applied Mathematical Analysis. II; 3 cr. Boundary value problems for partial differential equations, Fourier series and integrals, Bessel's and Legendre's functions; Laplace transform. Prereq: Math. 321 (113a).

342. (140) Survey of the Foundations of Arithmetic. SS only; 3 cr. A course of lectures for teachers; a critical study of the numbers and operations of elementary arithmetic; rational operations and their fundamental laws, scales of notation, the unique factorization theorem for integers, the rule of casting out nines, the greatest common divisor and least common multiple, the rational fractions, the real numbers, the complex numbers,

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functions, techniques of integration. Prereq: Math. 221 (60).

223. (62) Calculus and Analytic Geometry. I, II; 5 cr. Solid analytic geometry; partial derivatives; multiple integrals; infinite series, introduction to differential equations, and/or other topics in analysis. Prereq: Math. 222 (61).

231. (20) Calculus and Analytic Geometry. I, II; 4 cr. Analytic geometry of the straight line, circle, and conics; polynomials and their graphs; elements of the differential calculus, with applications involving polynomials. Prereq: Advanced mathematical preparation and a satisfactory score on the placement examination; or Math. 106 (6).

232. (21) Calculus and Analytic Geometry. I, II; 4 cr. Differential and integral calculus of algebraic and transcendental functions with applications to the physical and social sciences, further topics in analytic geometry. Prereq: Math. 231 (20).

233. (22) Calculus and Analytic Geometry. I, II; 4 cr. Infinite series, including Taylor's series; solid analytic geometry; partial derivatives; multiple integrals. Prereq: Math. 232 (21).

240. (31) Introductory Finite Mathematics. I, II; 4 cr. Elements of mathematical logic; structure in sets, partitions, and counting; probability theory; stochastic processes. Prereq: Intermediate mathematical preparation.

301. (101a) Calculus. I, II; 4 cr. Functions, limits, and derivatives; differentiation of algebraic function; differentials; integrals, differentiation of transcendental functions; applications; intended only for students transferring from other institutions. Prereq: Course in analytic geometry.

302. (101b) Calculus. I, II; 4 cr. Techniques of integration, partial derivatives, multiple integrals with applications to physics, infinite series. Prereq: Math. 301 (101a).

306. (117) Vector Analysis. Sem; 3 cr. The algebra and calculus of vectors with applications to analysis, geometry, and physics. Prereq: Math. 233 (22) or 223 (62).

307. (104) Theoretical Mechanics. Yr; 3 cr.

309. (137a) Introduction to Mathematical Statistics. [See Stat. 309 (137a).] I; 3 or 4 cr. Philosophy of the experimental method; distribution, univariate and multivariate; moments, expected values, variances; normal distribution and derived distributions, estimation, method of least squares. Prereq: Math. 233 (22), 302 (101b), 223 (62), or equiv.

310. (137b) Introduction to Mathematical Statistics. [See Stat. 310 (137b).] II; 3 or 4 cr. Analysis of variances; orthogonal polynomials; multifactor experimental designs, randomized blocks, factorial designs, composite designs; estimation of response relationships. Prereq: Math. 309 (137a).

313. (138) Actuarial Mathematics. Sem; 3 cr. Problems in finite differences, probability, and statistics with particular emphasis on applications to life insurance. Prereq: Math. 233 (22) or 223 (62).

321. (113a) Applied Mathematical Analysis. I; 3 cr. Selected topics in advanced calculus, mainly vector analysis, line and surface and integrals, Jacobians and physical applications. Prereq: Math. 419 (new; replacing old 111), 417 (112), or equiv.

322. (113b) Applied Mathematical Analysis. II; 3 cr. Boundary value problems for partial differential equations, Fourier series and integrals, Bessel's and Legendre's functions; Laplace transform. Prereq: Math. 321 (113a).

342. (140) Survey of the Foundations of Arithmetic. SS only; 3 cr. A course of lectures for teachers; a critical study of the numbers and operations of elementary arithmetic; rational operations and their fundamental laws, scales of notation, the unique factorization theorem for integers, the rule of casting out nines, the greatest common divisor and least common multiple, the rational fractions, the real numbers, the complex numbers, fractional and negative exponents, and logarithms. Prereq: Cons instr.

343. (141) Survey of the Foundations of Algebra. SS only; 3 cr. A course of lectures, primarily designed for teachers, on the fundamental concepts of elementary algebra.

344. (169) Topics in Classical Algebra. SS; 3 cr. Selected subjects from such topics as interpolation, combinatorial analysis, continued fractions, regions in which zeros of polynomials lie, and certain aspects of the theory of determinants. Prereq: Analytic geometry and calculus.

371-372. (107a-b) Basic Concepts of Mathematics. Yr; 3 cr. Foundations of number theory, algebra, geometry, and analysis, with attention to the historical background and the recent developments in these subjects; of primary interest to teachers in the secondary schools. Prereq: Cons instr.

413. (133) Introduction to Numerical Analysis. [See Computer Sci. 413 (133).] I, II; 3 cr. Finite difference calculus, summation calculus, roots of polynomials, polynomial approximation and least squares, numerical solution of ordinary differential and integral equations and numerical quadrature; selected topics in simulation and computer programming. Prereq: Math. 233 (22) or 223 (62).

415. (131) Theory and Operation of Computing Machines. [See Computer Sci. 415 (131).] I, II; 3 cr. Programming for digital computers. Number systems, Boolean algebra, machine language programming; design, implementation and use of computer languages; introduction to systems programming; survey of modern programming methods and applications. Prereq: Math. 233 (22) or 223 (62) and elementary knowledge of Fortran (or similar computer language) programming; or cons instr.

417. (112) Introduction to Differential Equations. Sem; 3 cr. A first course in the theory of differential equations; differs from Math. 419 (new) in that stress is laid on existence and general properties of functions defined by ordinary

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differential equations; recommended for mathematics majors, not open to students who have had Math. 317 (111). Prereq: Math. 233 (22) or 223 (62).

419. [Replaces Math. 317 (111)] Intermediate Differential Equations. Sem; 3 cr. Series solutions, systems of differential equations, boundary value problems and eigenfunction expansions, numerical methods, nonlinear equations and stability, rudimentary existence theory. Prereq: Math. 223 (62) and concurrent registration in 443 (114), or Math. 417 (112).

425. Linear Programming Methods. I, 3 cr. [See Computer Sci. 425 and Stat. 425.] A description of the simplex method, the revised simplex method, the dual simplex algorithm, and the primal-dual algorithm; special methods for solving transportation, tran-shipment, and assignment problems; parametric programming; exploitation of special structures of large-scale problems. Prereq: Math. 443 (114) or cons instr.

431. (118a) Introduction to the Theory of Probability. [See Stat. 431 (118a).] I; 3 cr. Probability in discrete sample spaces; combinatorial analysis; conditional probabilities, stochastic independence, Laplace limit theorem, Poisson distribution, laws of large numbers, random variables, applications to physics and statistics. Prereq: Math. 233 (22) or 223 (62).

432. (118b) Introduction to the Theory of Probability. [See Stat. 432 (118b).] II; 3 cr. Random walks, recurrent events, Markov chains, Poisson and other stochastic processes, and applications to physics and statistics. Prereq: Math. 431 (118a).

443. (114) Matrices and Their Applications. Sem; 3 cr. A course in matrix theory and linear algebra of interest to students whose main field of interest is not pure mathematics. Prereq: Math. 233 (22) or 223 (62).

461. (106) College Geometry I. Sem; 3 cr. An introduction to analytic and projective geometry including a study of the conic sections and quadric surfaces, of interest to teachers in secondary schools as well as mathematics students. Prereq: Concurrent registration in Math. 233 (22), 223 (62) or cons instr.

462. (108) College Geometry II. Sem; 3 cr. Includes such topics as the foundations of Euclidean and non-Euclidean geometry, isometry and similarity in Euclidean space, algebraic curves, *etc.* Prereq: Math. 461 (106).

463. (109) Topics in Geometry. SS; 3 cr. A course to broaden the understanding of high-school geometry by discussion of related elementary, but modern, topics; of primary interest to teachers in secondary schools. Prereq: Math. 462 (108) or cons instr.

473. (173) History of Mathematics. Sem; 3 cr. A survey of the main lines of mathematical development from the Babylonians, Egyptians and Greeks to the present day; the lives of great mathematicians; Euclid, Archimedes, Descartes, Newton, Gauss, *etc.* Prereq: Cons instr.

511. (113) Symbolic Logic. [See Philos. 511 (113).] I, II; 3 cr. Formal characterization of logical truth and deductive inference, with special emphasis on the construction and discussion of symbolic systems in axiomatic form. Prereq: Cons instr.

521. (120a) Advanced Calculus. Sem; 3 cr. Fundamental notions of limits continuity, differentiation, and integration, for functions of one or more variables, convergence and uniform convergence of infinite series, and improper integrals; applications. Prereq: Math. 233 (22) or 223 (62).

522. (120b) Advanced Calculus. Sem; 3 cr. Differentials and Jacobians, transformation of coordinates and of multiple integrals, line and surface integrals, special methods. Prereq: Math. 521 (120a).

541. (115a) Modern Algebra. I; 3 cr. Vector spaces, linear transformations and matrices, systems of linear equations, determinants, characteristic roots and the minimal polynomial, groups of linear transformations. Prereq: Math. 233 (22) or 223 (62). Math. 443 (114) and 541 (115a) may not both be taken for credit.

542. (115b) Modern Algebra. II; 3 cr. Unique factorization of integers and polynomials, polynomial equations, fields, rings, groups, homomorphisms. Prereq: Math. 541 (115a).

551. (121) Elementary Topology. Sem; 3 cr. Topological properties of sets in Euclidean space, and an introduction to the general theory of metric and topological spaces. Prereq: Math. 233 (22) or 223 (62).

561. (119) Differential Geometry. II; 3 cr. Theory of curves and surfaces by differential methods. Prereq: Math. 233 (22) or 223 (62).

563. (122) Projective Geometry. Sem; 3 cr. Analytic and synthetic projective geometry; finite planes, non-Desarquesian planes, and the algebraic structures associated with them. Prereq: Math. 443 (114), 541 (115a), or cons instr.

565. (123) Convex Figures and Inequalities. Sem; 3 cr. Introductory course dealing with the simplest geometrical properties of convex figures and with their applications to the fundamental inequalities in use in everyday mathematical analysis. Prereq: Cons instr.

567. (166a) Elementary Number Theory. Sem; 3 cr. Fundamental theorem of arithmetic, quadratic residues and quadratic reciprocity, number-theoretic functions, certain diophantine equations, Farey fractions, continued fractions. Prereq: Cons instr.

568. (166b) Elementary Number Theory. Sem; 3 cr. Elementary prime number theory, Minkowski's theorem, Gaussian integers, unique factorization in quadratic fields, higher-residues, irrational numbers, approximation by rational numbers. Prereq: Cons instr or Math. 567 (166a).

623. (116) Complex Analysis. I; 3 cr. Elementary functions of a complex variable; conformal mapping; complex integrals; the calculus of residues. Prereq: Math. 521 (120a).

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of interest to teachers in secondary schools as well as mathematics students. Prereq: Concurrent registration in Math. 233 (22), 223 (62) or cons instr.

62. (108) College Geometry II. Sem; 3 r. Includes such topics as the foundations of Euclidean and non-Euclidean geometry, isometry and similarity in Euclidean space, algebraic curves, *etc.* Prereq: Math. 461 (106).

63. (109) Topics in Geometry. SS; 3 . A course to broaden the understanding of high-school geometry by discussion of related elementary, but modern, topics; of primary interest to teachers in secondary schools. Prereq: Math. 462 08) or cons instr.

3. (173) History of Mathematics. Sem; r. A survey of the main lines of mathematical development from the Babylonians, Egyptians and Greeks to the present day; the lives of great mathematicians; Euclid, Archimedes, Descartes, Newton, Gauss, *etc.* Prereq: Cons r.

. (113) Symbolic Logic. [See Philos. (113).] I, II; 3 cr. Formal characterion of logical truth and deductive inference, with special emphasis on the construction and discussion of symbolic ems in axiomatic form. Prereq: Cons

(120a) Advanced Calculus. Sem; 3 Fundamental notions of limits conuity, differentiation, and integration, unctions of one or more variables, ergence and uniform convergence of te series, and improper integrals; cations. Prereq: Math. 233 (22) or 62).

(120b) Advanced Calculus. Sem; 3 Differentials and Jacobians, transtion of coordinates and of multiple als, line and surface integrals, spethods. Prereq: Math. 521 (120a).

(115a) Modern Algebra. I; 3 cr. spaces, linear transformations and es, systems of linear equations, deants, characteristic roots and the al polynomial, groups of linear rmations. Prereq: Math. 233 (22) or 223 (62). Math. 443 (114) and 541 (115a) may not both be taken for credit.

542. (115b) Modern Algebra. II; 3 cr. Unique factorization of integers and polynomials, polynomial equations, fields, rings, groups, homomorphisms. Prereq: Math. 541 (115a).

551. (121) Elementary Topology. Sem; 3 cr. Topological properties of sets in Euclidean space, and an introduction to the general theory of metric and topological spaces. Prereq: Math. 233 (22) or 223 (62).

561. (119) Differential Geometry. II; 3 cr. Theory of curves and surfaces by differential methods. Prereq: Math. 233 (22) or 223 (62).

563. (122) Projective Geometry. Sem; 3 cr. Analytic and synthetic projective geometry; finite planes, non-Desarquesian planes, and the algebraic structures associated with them. Prereq: Math. 443 (114), 541 (115a), or cons instr.

565. (123) Convex Figures and Inequalities. Sem; 3 cr. Introductory course dealing with the simplest geometrical properties of convex figures and with their applications to the fundamental inequalities in use in everyday mathematical analysis. Prereq: Cons instr.

567. (166a) Elementary Number Theory. Sem; 3 cr. Fundamental theorem of arithmetic, quadratic residues and quadratic reciprocity, number-theoretic functions, certain diophantine equations, Farey fractions, continued fractions. Prereq: Cons instr.

568. (166b) Elementary Number Theory. Sem; 3 cr. Elementary prime number theory, Minkowski's theorem, Gaussian integers, unique factorization in quadratic fields, higher-residues, irrational numbers, approximation by rational numbers. Prereq: Cons instr or Math. 567 (166a).

623. (116) Complex Analysis. I; 3 cr. Elementary functions of a complex variable; conformal mapping; complex integrals; the calculus of residues. Prereq: Math. 521 (120a).

629. (125) Introduction to Measure and Integration. II; 3 cr. Measure of point sets on the line; the structure of measurable functions on the line and the Lebesque integral, basic for advanced work in probability and statistics; desirable for advanced work in analysis and applied mathematics. Prereq: Math. 421 (120a), 551 (121), or cons instr.

671. (150) Modern Views of Mathematics. 2 or 3 cr.

681-682. (100) Senior Thesis. *cr.

699. (180) Independent Reading. *cr.

Graduate Courses

701. (213a) Mathematical Methods in Physics and Engineering. Sem; 3 cr. Vector spaces, matrices, Lebesque integrals, distributions, approximation in normed spaces and Hilbert space; Fourier, Legendre and Hermite series; spherical harmonics. Prereq: Math. 419, 521 (120a), 522 (120b), or equiv.

702. (213b) Mathematical Methods in Physics and Engineering. Sem; 3 cr. Fourier and Laplace transforms, eigenvalue and boundary value problems, integral equations, calculus of variations. Prereq: Math. 701 (213a).

705. (249) Hydro and Aerodynamics. Sem; 3 cr. Prereq: Cons instr.

706. (217) Tensor Analysis. Sem; 3 cr. Algebra and calculus of tensors with particular emphasis on their applications to the theory of relativity. Prereq: Cons instr.

707-708. (250a-b) Theory of Elasticity. 3 cr.

709. (237a) Mathematical Statistics. Sem; 4 cr. Multivariate analysis, sequential analysis, nonparametric inference. Prereq: Math. 310 (137b).

710. (237b) Mathematical Statistics. Sem; 4 cr. Prereq: Math. 709 (237a).

715-716. Introduction to Applied Mathematics and Numerical Analysis. Yr; 3 cr. The mathematical formulation of physical problems; exact and approximate methods for solving the resulting equations. Prereq: 321-322 (113a-b), and 443 (114), or equiv.