the way in which they inform the epistemological configurations of a
and a founding and finished one (Descartes).

:he, Musil, Stendhal, and Zola in the context of recent theoretical
and status of description in novelistic discourse. The course will
al and the ideological through a close analysis of the complex relation
y texts will be selected from the work of Hamon, Genette, Barthes,
akhtin, Auerbach and others.

ll as a selection of her essays, letters and translations in the context
heoretical discussions of what to make of fiction generally. The fall
ch, then turn back to the beginning of her career to consider her
early fiction, through "The Lifted Veil" (1859). In the spring term
60) and continue through *Daniel Deronda* (1876) and *Impressions*

ading
of recent Continental and Anglo-American critical approaches to
ext, authorship, and audience.

on
production in the development of the 19th-century literary canon.

/ and the behavioral sciences from their origins in 19th-century
es of their evolution in the 20th century, with special emphasis on
ed include: the history of association psychology; the founding of
:an psychology (William James, E. B. Titchener, Stanley Hall);
nd behaviorism; the history of mental testing; gestalt psychology;
al sciences.

attempts have been made to determine the uniqueness or essence
at are we to make of such attempts and how can their validity be
edium emerged as a principal characteristic of the modernist arts
How have the realms of the pictorial and the literary been distin-
e? And what are the implications for the issue of purity of recent
' These and related topics will be pursued chiefly in connection
laire, Pater, Fry, Greenberg, and Derrida; with recent debates
post-modernism; and with actual paintings by modernist masters
equired.

erman texts in the light of Romantic poetics and contemporary

l to students writing dissertations.

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ound the history of art have begun to hold out the promise of an
nar we will consider a number of those developments, chiefly
writers such as Alpers, T.J. Clark, Steinberg, Summers, Baxan-
nter, Marin, Barthes, Foucault, Derrida, Kristera, Serres, and
uired.

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35.61 Dante's *Inferno*
Singleton 3 credits
35.352 Dante's *Purgatory*
Singleton 3 credits
80.313 (H) Introduction to Greek and Roman Mythology
This introductory course is intended to acquaint students with the most important myths through translation of various primary sources of classical myths in Greek and Roman literature. Illustrations of the subjects in ancient and modern art are used. Attention is drawn to the connection between the myths of various gods and the origins of drama, festivals, and games.
Zintl 3 credits
80.319 (H) Seminar in Greek and Roman Political Thought
Kelly
80.325 Liberalism as Force and Idea
Kelly
80.326 (H) Seminar in Greek and Roman Mythology
Prerequisite: 80.313 or by permission of instructor.
Zintl 3 credits
80.334 19th-Century German Philosophy
Schneewind
80.336 Seminar: Modes and Meanings of Death in 18th-Century France
Kelly
80.369 Seminar: 18th-Century French Political and Social Thought
Kelly
80.681 Seminar: Hegel's Phenomenology of Spirit
Kelly

Semesters

INTERDEPARTMENTAL

When two or more departments combine to offer a course, it is called an interdepartmental course and it will be listed under each of those departments with the course designator 80.

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INTERNATIONAL STUDIES

See the Department of Political Science.

ITALIAN

See the Department of Hispanic and Italian Studies.

MATHEMATICS

The Department of Mathematics offers programs at the undergraduate and graduate levels. The undergraduate program provides opportunities for students who are interested in mathematics as a future career or as an adjunct to other fields. A flexible program involving a broad selection of courses is a department tradition. Students who are interested in applications may choose upper division courses in the areas of analysis and differential equations, while students contemplating further study in mathematics may select courses in advanced algebra, analysis, topology, and differential geometry. Qualified students are encouraged to enroll in graduate level courses in their junior or senior years, and can be admitted to graduate study while completing requirements for the B.A. degree.

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The graduate program is primarily designed to prepare students for research and teaching in mathematics, and naturally it is centered around the research areas of the faculty. These include functional analysis, ordinary and partial differential equations, differential geometry and global analysis, algebraic geometry, algebraic number theory, topology, several complex variables, algebraic groups and representation theory. The program can easily be supplemented in more applied directions by courses in mechanics, probability, etc., offered in other departments.

The Faculty

Professor John M. Boardman (Chairman): algebraic and differential topology.
Professor Emeritus Wei-Liang Chow: algebra, algebraic geometry, complex varieties.
Professor Jun-Ichi Igusa: algebra, algebraic geometry, modular functions, number theory.
Professor George Kempf: algebraic geometry.
Professor Jean-Pierre Meyer: algebraic topology, category theory.
Professor Jack Morava: algebraic topology.
Professor Takashi Ono: algebra, number theory, algebraic groups.
Professor Joseph H. Sampson: differential geometry, global analysis, algebraic geometry.
Professor Joseph A. Shalika: algebraic groups and representations, number theory.
Professor Bernard Shiffman: several complex variables, differential geometry.
Professor W. Stephen Wilson: algebraic topology.
Associate Professor Robert W. Thomason: algebraic K-theory, algebraic geometry.
Associate Professor Steven Zucker: differential geometry, algebraic geometry.
Assistant Professor Dinakar Ramakrishnan: value of L-functions, group representations.
Assistant Professor Loring W. Tu: algebraic geometry, differential geometry.

Undergraduate Programs

See also General University Distribution Requirements, page 44.

The mathematics program usually begins with calculus, which is offered at several levels to meet the needs of students with various backgrounds and goals. A one-term pre-calculus course 11.5 is offered for students with insufficient high school preparation in the elementary tools (algebra and trigonometry) used in the calculus.

The department does not give advanced placement examinations, but advanced placement and credit are awarded on the basis of Advanced Placement Examinations of the College Entrance Examinations Board (see page 14).

Students in the biological and social sciences are encouraged to begin with the 11.8-9 calculus sequence which aims at showing how to use the methods of calculus. This may be followed by 11.13, 11.302. The course 11.302, taught at an elementary level, is especially designed to acquaint the students with more advanced mathematical methods of importance in the biological, social and physical sciences.

It is suggested that students in the natural sciences begin with the 11.8-9 calculus sequence. This should be followed by 11.12 and 11.13. Upper division courses oriented toward applicable mathematics are 11.302, 11.311, 11.316, 11.317, 11.335-36, 11.341, 11.343 and 11.350. For the mathematically oriented student, a variety of courses in theoretical and applied mathematics is also offered at the 300 level. Students interested in pursuing further study in mathematics should work towards taking advanced courses as early as possible in their undergraduate years, and are encouraged to take graduate level courses as soon as they are qualified.

rimarily designed to prepare students for research and naturally it is centered around the research areas of the nal analysis, ordinary and partial differential equations, al analysis, algebraic geometry, algebraic number theory, iables, algebraic groups and representation theory. The iented in more applied directions by courses in mechan- n other departments.

(Chairman): algebraic and differential topology.
Chow: algebra, algebraic geometry, complex varieties,
bra, algebraic geometry, modular functions, number

raic geometry.
lgebraic topology, category theory.
ic topology.
, number theory, algebraic groups.
differential geometry, global analysis, algebraic geom-

gebraic groups and representations, number theory,
veral complex variables, differential geometry,
algebraic topology.
Thomason: algebraic K-theory, algebraic geometry.
er: differential geometry, algebraic geometry.
akrishnan: value of L-functions, group representations,
u: algebraic geometry, differential geometry.

ribution Requirements, page 44.
lly begins with calculus, which is offered at several nts with various backgrounds and goals. A one-term d for students with insufficient high school prepara- bra and trigonometry) used in the calculus.
advanced placement examinations, but advanced d on the basis of Advanced Placement Examinations tions Board (see page 14).
ocial sciences are encouraged to begin with the 11.8-9 showing how to use the methods of calculus. This The course 11.302, taught at an elementary level, is the students with more advanced mathematical logical, social and physical sciences.
the natural sciences begin with the 11.8-9 calculus ved by 11.12 and 11.13. Upper division courses natics are 11.302, 11.311, 11.316, 11.317, 11.335-36, the mathematically oriented student, a variety of mathematics is also offered at the 300 level. Stu- r study in mathematics should work towards taking le in their undergraduate years, and are encouraged on as they are qualified.

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Combined B.A./M.A. Program
By applying the same courses simultaneously towards the requirements for the B.A. and M.A. degrees, an advanced student can qualify for both degrees. Admission to the program is by the standard graduate application form, which is typically filed in the junior year. Contact the Department graduate secretary for further information.

Departmental Requirements for the Bachelor of Arts Degree
In addition to the general University requirements on pages 41 and 44, a candidate for the bachelor's degree in mathematics is required to have credit for the following courses (it is to be understood that the same course or substantially overlapping courses cannot be used to fulfill more than one of the requirements): (1) 11.12, Calculus III; (2) two terms of algebra (such as 11.14 or 11.303-304, but 11.13 does not qualify); (3) two terms of analysis (such as 11.302, 11.305-306, 11.311-312, 11.316, 11.317, 11.335-336, 11.341, 11.343, or 11.350); (4) two terms of mathematics selected from 11.13, 11.14, courses at the 300-level or above, and other courses as noted below; (5) two terms at the 300-level of at least one topic involving applications of mathematics, selected from the courses listed below.

Suitable courses for (5) are 17.300, 17.305-306, and 17.312 in physics, 55.315-316 and 55.341-342 in probability and statistics, 55.345-346 in optimization theory, 55.365-366 in numerical analysis, 3.353-354 in chemistry, and 52.335 and 52.356 in electrical engineering. Other appropriate courses may be taken instead, upon approval of the chairman.

One or both of the terms in (4) can be satisfied, upon approval of the chairman, by courses in probability, statistics, or computer science (in the Mathematical Sciences Department), mechanics and elasticity (Mechanics Department), or advanced mechanics and quantum physics (Physics and Astronomy Department).

Students expecting to pursue graduate studies in mathematics are advised to take 11.303-304, 11.311-312 and 11.313 (and, if possible, 11.605-606).

Graduate Programs

Graduate study is centered around six basic courses, 11.605-606, 11.611-612, 11.615-616, 11.617-618, 11.619-620, 11.643-644. These are built upon the foundations constituted by the fundamental 300-level courses 11.303-304, 11.311-312, 11.313. Some entering graduate students will need one or more of the latter as preparation, but it is expected that at least one of the basic 600-level courses will be part of the first year program.

These courses are intended to bring students abreast of current developments in the respective areas, and to prepare students to begin research study in the area of their choice. As will be seen from the course listings, the graduate programs in the mathematics department are in algebraic geometry, algebraic groups and number theory, algebraic topology, analysis, differential geometry and symmetric spaces, group representations, and closely related topics.

Departmental Requirements for Advanced Degrees
Admission to the department to do advanced study will be based on previous records, letters of recommendation, and Graduate Record Examination scores. The department accepts applicants who intend to become candidates for either the M.A. or Ph.D. degree. Students who expect to study mathematics beyond the B.A. degree are urged to acquire a reading knowledge of French and German.

Master of Arts See page 51 for the general University requirements. The Departmental requirements for the M.A. degree are: (1) a thorough knowledge of algebra,

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complex analysis, and topology at least equivalent to what is provided by Mathematics 11.303-304, 11.311-312, 11.313, and one other course in topology (such as 11.318, 11.361, or 11.363); (2) a deeper knowledge, demonstrated by a special Qualifying Examination, of the field of mathematics covered by one of the six basic graduate courses 11.605-606, 11.611-612, 11.615-616, 11.617-618, 11.619-620, or 11.643-644; (3) completion, while resident at the University, of one of the basic 600-level courses listed under (2) and at least two other terms of courses at the 300-level or above; (4) for candidates for the B.A./M.A. degree, at least a B average in the 300-level mathematics courses taken while resident at the University; (5) a reading knowledge of French, German, or Russian, as shown by an examination given by this Department.

Doctor of Philosophy Attention is invited to the statement on University degree requirements under Academic Information for Graduate Students. The Graduate Board Oral Examination referred to there is a final examination for the Department of Mathematics. The departmental requirements for the Ph.D. degree are as follows: (1) a reading knowledge of two of the following: French, German, or Russian, to be exhibited by passing examinations given in the Mathematics Department; (2) a broad knowledge of mathematics, including standard undergraduate-level mathematics and the fields covered by the six basic graduate courses 11.605-606, 11.611-612, 11.615-616, 11.617-618, 11.619-620, 11.643-644; with permission of the Chairman, one or two of these courses may be replaced by applied mathematics or related courses in other departments; (3) passing, normally within the first two years of study, special qualifying examinations in three of the basic 600-level mathematics courses; (4) some teaching of mathematics, usually at the undergraduate level, under the supervision of a faculty member; (5) a written dissertation based on independent research and judged acceptable by two faculty members appointed by the department; (6) the final Graduate Board Oral Examination which is the dissertation defense. For further information on graduate programs please contact the Chairman or the Graduate Admissions Committee.

Facilities

The University library has an unusually extensive collection of mathematics literature, including all the important current journals. The stacks are open to students. The department also has a useful local reference library. Convenient places for study are provided in the main library and in departmental offices reserved for graduate students.

Fellowships

At this time the University supplies a number of teaching assistantships and tuition fellowships as described at the back of the catalog, in the section on Fellowships. Financial assistance is normally available to Ph.D. candidates only.

C

UNDERGRADUATE COURSES

11.5 (Q) Pre-Calculus Mathematics
This course is intended primarily for students with insufficient preparation in the elementary tools needed for calculus, and will deal principally with topics in algebra and trigonometry usually covered in high school courses. It includes a study of polynomial, rational, exponential, logarithmic and trigonometric functions, with emphasis on graphing techniques, numerical aspects, and applications; also an introduction to analytic geometry and other topics as time permits.
4 credits Offered fall term

y at least equivalent to what is provided by Mathemat-
.313, and one other course in topology (such as 11.318,
per knowledge, demonstrated by a special Qualifying
mathematics covered by one of the six basic graduate
2, 11.615-616, 11.617-618, 11.619-620, or 11.643-644,
at the University, of one of the basic 600-level courses
o other terms of courses at the 300-level or above; (4) for
degree, at least a B average in the 300-level mathematics
the University; (5) a reading knowledge of French, Ger-
an examination given by this Department.

on is invited to the statement on University degree re-
formation for Graduate Students. The Graduate Board
there is a final examination for the Department of
al requirements for the Ph.D. degree are as follows:
of the following: French, German, or Russian, to be ex-
is given in the Mathematics Department; (2) a broad
luding standard undergraduate-level mathematics and
ix basic graduate courses 11.605-606, 11.611-612,
-620, 11.643-644; with permission of the Chairman,
be replaced by applied mathematics or related courses
ig, normally within the first two years of study, special
e of the basic 600-level mathematics courses; (4) some
ly at the undergraduate level, under the supervision of
dissertation based on independent research and judged
bers appointed by the department; (6) the final Grad-
which is the dissertation defense. For further infor-
please contact the Chairman or the Graduate Admis-

usually extensive collection of mathematics literature,
nt journals. The stacks are open to students. The de-
reference library. Convenient places for study are pro-
departmental offices reserved for graduate students.

plies a number of teaching assistantships and tuition
back of the catalog, in the section on Fellowships.
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opics in algebra and trigonometry usually covered in high school
rational, exponential, logarithmic and trigonometric functions, with
al aspects, and applications; also an introduction to analytic geome-

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11.8-9 (Q) Calculus I and II
Differential and integral calculus. Includes analytic geometry, functions, limits, integrals and derivatives. Taylor's theorem and applications, infinite series, complex numbers, introduction to differential equations. Some applications to the sciences and engineering will be discussed.
4 credits per term Each offered both terms = semesters

11.12 (Q) Calculus III—Calculus of Several Variables
A continuation of 11.8-9, with applications to functions of more than one variable: partial derivatives, Taylor's theorem, power series; multiple integrals, line and surface integrals; an introduction to vector analysis. Prerequisite: Calculus I-II.
4 credits Offered both terms

11.13 (Q) Linear Algebra
Vector spaces, matrices and linear transformations. Eigenvalues, eigenvectors, triangulation and diagonalization of matrices. Applications to other branches of mathematics and the sciences will be covered, as time permits. Prerequisites: none.
4 credits Offered both terms Semesters

11.14 (Q) Elementary Number Theory
The student is provided with many historical examples of topics each of which serves as an illustration of and provides a background for many years of current research in number theory. This course also provides the student with concrete examples of general abstract concepts studied in 11.303-304. Primes and prime factorization, congruences, Euler's function, quadratic reciprocity, primitive roots, solutions to polynomial congruences (Chevalley's theorem), Diophantine equations including the Pythagorean and Pell equations, Gaussian integers, Dirichlet's theorem on primes. Prerequisite: A good high school background including a year of calculus.
4 credits

11.20 (Q) From Ancient Accounting to Modern Mathematics
Primarily designed for non-science majors. Basic concepts of mathematics and their cultural, historical context. Prerequisites: High-school algebra and geometry.
4 credits

11.302 (Q) Elements of Differential Equations
This is an applied course in ordinary differential equations, which is primarily for students in the biological, physical and social sciences and engineering. The purpose of the course is to familiarize the student with the techniques of solving ordinary differential equations. The specific subjects to be covered include: first order differential equations, second order linear differential equations, applications to electric circuits, oscillation of solutions, power series solutions, systems of linear differential equations, autonomous systems, Laplace transforms and linear differential equations, mathematical models (e.g., in the sciences or economics). Prerequisite: Calculus I-II.
4½ credits Offered both terms

11.303-304 (Q) Introduction to Advanced Algebra
The basic notions of modern algebra; fundamental theorems on groups, rings, fields, vector spaces, and modules; Galois theory; commutative rings; selected topics. Prerequisite: 11.13.
4½ credits per term

11.305 (Q) Analysis I
This course is a sequel to Calculus III and is designed to give a firm grounding in the basic tools of analysis. It is recommended as preparation (but may not be a prerequisite) for more advanced analysis courses. Real and complex numbers, limits, continuity, infinite sequences and series, l'Hopital's rule, functions of bounded variation and Riemann-Stieltjes integration, sequences of functions. Prerequisite: Calculus III.
4½ credits Offered fall term

11.306 (Q) Analysis II
A continuation of 11.305. Possible topics include: Fundamental inequalities of analysis. Metric spaces: review of topology of Euclidean spaces, limits, continuity, completeness, normed and Banach spaces (with emphasis on the standard function spaces C^0, BV, L^P and on l^P); the contraction principle and applications (implicit function theorem, existence theorems for ordinary differential equations); separability; compactness in Euclidean spaces, in C^0 (Arzela-Ascoli theorem), in BV (Helly's theorems). Topics in functional analysis as time permits: Hahn-Banach theorem, strong and weak convergence, bounded operators, adjoint operators, compact operators. Prerequisites: Calculus III and Linear Algebra.
4½ credits Offered spring term

11.307-308 (Q,N) Geometry and Relativity
Special relativity: Lorentz transformation, Minkowski spacetime, mass, energy-momentum, stress-energy tensor, electrodynamics. Introduction to differential geometry: theory of surfaces, first and second fundamental forms, curvature, Gauss's *theorema egregium*, differentiable manifolds, connections and covariant differentiation, geodesics, differential forms, Stokes theorem. Gravitation as a geometric theory: Lorentz metrics, Riemann curvature tensor, tidal forces and geodesic deviation, gravitational redshift, Einstein field equation, the Schwarzschild solution, perihelion precession, the deflection of light, black holes, cosmology. Prerequisites: 11.12; 11.13; General Physics I and II or equivalent.
4½ credits per term

11.311 (Q) Methods of Complex Analysis
This course is an introduction to the theory of functions of one complex variable. Its emphasis is on techniques and applications, and it serves as a basis for more advanced courses. Functions of a complex variable and their

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derivatives; power series and Laurent expansions; Cauchy integral theorem and formula; calculus of residues and contour integrals; harmonic functions; conformal mapping. Prerequisite: Calculus III.
4½ credits Offered fall term

11.312 (Q) Complex Function Theory
This is a continuation of 11.311 with an emphasis on the theory of functions of complex variables. It is a useful introduction to more advanced courses in complex analysis and geometry (such as 11.611-612 or 11.643-644). Dirichlet problem; normal families; conformal mapping; Riemann mapping theorem; Weierstrass products; elliptic functions and integrals; algebraic functions, Riemann surfaces. Prerequisite: 11.311 or consent of instructor; 11.305 is recommended.
4½ credits Offered spring term

11.313 (Q) Point Set Topology
The basic concepts of general topology: topological spaces, metric spaces, compactness, connectedness. Covering spaces and the fundamental group. This course is the foundation for other courses in topology and analysis. Prerequisites: Calculus III.
4½ credits Offered fall term.

11.316 (Q) Ordinary Differential Equations
This course is of a more theoretical nature than 11.302. Solutions of standard types of ordinary differential equations, existence and uniqueness of solutions, differential inequalities, linear systems and linear equations, adjoint equations, linear equations in the complex plane (and regular singular points), classical equations, oscillations and second order equations, Sturm- Liouville boundary value problems, stability and asymptotic integration of linear and perturbed linear systems. Prerequisites: Calculus III and Linear Algebra; 11.305 is recommended.
4½ credits

11.317 (Q) Partial Differential Equations
Characteristics, classification of second order equations, well-posed problems, separation of variables and expansions of solutions. The wave equation: Cauchy problem, Poisson's solution, energy inequalities, domains of influence and dependence. Laplace's equation: Poisson's formula, maximum principles, Green's functions, potential theory, Dirichlet and Neumann problems, eigenvalue problems. The heat equation: fundamental solutions, maximum principles. Prerequisites: Calculus III and Linear Algebra; 11.305 is recommended
4½ credits Offered spring term

11.318 (Q) Introduction to Manifolds
Differential manifolds, tangent bundle, differential forms, Stokes' theorem, de Rham cohomology, topological groups. Prerequisites: 11.313 and Linear Algebra.
4½ credits

11.325 (Q) Algebraic Geometry
An introduction to the classical geometry of the solution sets of systems of algebraic equations. Ideals, modules, Noetherian rings, function fields, rational functions, local rings. The correspondence between algebra and geometry, Hilbert's Nullstellensatz, Riemann-Roch theorem. Projective space, Bézout's theorem on the intersection of curves, the Zariski topology, abstract algebraic varieties. Prerequisite: 11.303. 11.304 is recommended.
4½ credits

11.335-336 (Q) Advanced Mathematics for Applications
L^2-spaces, Fourier series, Fourier transform, special functions, expansions by orthogonal functions, contour integrals of complex functions, residues, integral equations, some partial differential equations. This course is being designed especially for engineering majors and course material is still under consideration. It is intended to acquaint students with a substantial array of the linear methods of use in applications of mathematics to engineering. Prerequisites: Calculus III and Linear Algebra.
4½ credits per term

11.339 (Q) Introduction to Differential Geometry
Theory of curves and surfaces in Euclidean space: Frenet equations, fundamental forms, curvatures of a surface, theorems of Gauss and Mainardi-Codazzi, curves on a surface; introduction to tensor analysis and Riemannian geometry; theorema egregium; elementary global theorems. Prerequisites: Calculus III and Linear Algebra.
4½ credits

11.341 (Q) Asymptotic Methods
Techniques for finding approximations to integrals and solutions of differential equations. Topics include: Laplace's method, method of steepest descent, method of stationary phase. WKB, turning points, connection problems, etc. Applications to Stirling's formula, asymptotic expansion of Airy and Bessel function. Prerequisites: Calculus III and some knowledge of complex variables (contour integration and calculus of residues, as covered, e.g., in 11.311).
4½ credits

11.343 (Q) Fourier Analysis and Generalized Functions
Trigonometric Fourier series (Riemann-Lebesgue lemma, convergence and summability, Poisson's formula). Complete orthonormal systems, Parseval's relation, completeness. Fourier transforms of L^1-functions. L^2-functions (Plancherel theorem); Fourier transforms and derivatives, convolutions, the theory of generalized functions ("distributions"). The material will be illustrated by applications to partial differential equations. Prerequisites: Calculus III and Linear Algebra.
4½ credits

pansions; Cauchy integral theorem and formula; calculus of residues
ıs; conformal mapping. Prerequisite: Calculus III.

:mphasis on the theory of functions of complex variables. It is a useful
ı complex analysis and geometry (such as 11.611-612 or 11.643-644).
formal mapping; Riemann mapping theorem; Weierstrass products;
functions, Riemann surfaces. Prerequisite: 11.311 or consent of in-

ɔpological spaces, metric spaces, compactness, connectedness. Cover-
his course is the foundation for other courses in topology and analysis.

ns
re than 11.302. Solutions of standard types of ordinary differential
lutions, differential inequalities, linear systems and linear equations,
e complex plane (and regular singular points), classical equations,
Sturm- Liouville boundary value problems, stability and asymptotic
r systems. Prerequisites: Calculus III and Linear Algebra; 11.305 is

der equations, well-posed problems, separation of variables and ex-
Cauchy problem, Poisson's solution, energy inequalities, domains of
ıation: Poisson's formula, maximum principles, Green's functions,
problems, eigenvalue problems. The heat equation: fundamental
tes: Calculus III and Linear Algebra; 11.305 is recommended

fferential forms, Stokes' theorem, de Rham cohomology, topological
Algebra.

y of the solution sets of systems of algebraic equations. Ideals,
ds, rational functions, local rings. The correspondence between
nsatz, Riemann-Roch theorem. Projective space, Bézout's theorem
topology, abstract algebraic varieties. Prerequisite: 11.303, 11.304

Applications
m, special functions, expansions by orthogonal functions, contour
tegral equations, some partial differential equations. This course is
ıajors and course material is still under consideration. It is intended
y of the linear methods of use in applications of mathematics to en-
Linear Algebra.

ometry
ı space: Frenet equations, fundamental forms, curvatures of a sur-
odazzi, curves on a surface; introduction to tensor analysis and
n; elementary global theorems. Prerequisites: Calculus III and

integrals and solutions of differential equations. Topics include:
ent, method of stationary phase. WKB, turning points, connection
mula, asymptotic expansion of Airy and Bessel function. Prerequi-
complex variables (contour integration and calculus of residues, as

d Functions
esgue lemma, convergence and summability. Poisson's formula.
s relation, completeness. Fourier transforms of L^1-functions,
transforms and derivatives, convolutions, the theory of generalized
ill be illustrated by applications to partial differential equations.
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11.350 (Q) Hilbert Spaces and Linear Operators
Introductory course to Hilbert spaces and their applications; Hilbert space, geometric properties of Hilbert space (orthogonal projections, orthogonal bases, weak and strong convergence), examples (especially, orthogonal functions), linear operators (boundedness, adjoint operators, self-adjoint operators), discussion of the spectral theorem, compact operators and the Fredholm alternative, integral operators and integral transforms (Fourier, Hilbert), introduction to differential operators. Prerequisite: Calculus III and Linear Algebra.
4½ credits

11.361 (Q) Differential Topology
Differentiable manifolds and their tangent bundle. Differentiable mappings. Transversality theory. Elementary Morse theory. Applications.
4½ credits

11.363 (Q) Elementary Algebraic Topology
An undergraduate introduction to 11.615-616. The basic geometric ideas will be emphasized, rather than the development of the abstract formalism. Simplicial complexes and mappings; an introduction to singular homology theory; combinatorial manifolds and Poincaré duality (the classical approach); elementary applications.
4½ credits

11.392 (Q) Undergraduate Seminar
1½ credits, pass-fail only Offered spring term

GRADUATE COURSES

11.605-606 Real Variables
Measure and integration on abstract and locally compact spaces (extension of measures, decompositions of measures, product measures, integrals, term-by-term integration, L_p-spaces); introduction to functional analysis; integration on groups; Fourier transforms. Prerequisite or corequisite: General Topology (e.g., 11.313).

11.611-612 Complex Varieties
Complex spaces, analytic local rings, Weierstrass preparation theorem, sheaves and cohomology on analytic spaces, Stein manifolds. Theorems A and B and their application to Chow's theorem, and the Riemann-Roch theorem. Prerequisite: 11.311-312, 11.313, or equivalent.

11.615-616 Algebraic Topology
Polyhedra, simplicial and singular homology theory, Lefschetz fixed-point theorem, cohomology and products, homological algebra, Künneth and universal coefficient theorems, Poincaré and Alexander duality theorems. Prerequisites: 11.303, 11.313.
Offered alternate years

11.617-618 Fundamental Number Theory
Topics in advanced algebra and number theory, including local fields and adeles, Iwasawa-Tate theory of zeta-functions and connections with Hecke's treatment, semi-simple algebras over local and number fields, adele geometry. Prerequisite: 11.303-304.

11.619-20 Lie Groups and Lie Algebras
Lie groups and Lie algebras, classification of complex semi-simple Lie algebras, compact forms, representations and Weyl formulas, symmetric Riemmanian spaces. Prerequisites: 11.304 and 11.318.

11.643-644 Algebraic Geometry
Hilbert's theorems about polynomials in several variables with their connections to geometry. Affine varieties and spectral theory. General varieties and projective geometry. Dimension theory and smooth varieties. Sheaf theory and cohomology. Applications of sheaves to geometry; e.g., the Riemann-Roch Theorem. Other topics may include Jacobian varieties, resolution of singularities, geometry on surfaces, schemes, connections with complex analytic geometry and topology. Prerequisite: 11.303-304.

11.645 Differential Geometry
Differential manifolds, vector fields, flows, Frobenius' theorem, differential forms, deRham's theorem, vector bundles, connections, curvature, Cartan structure equations, Riemannian manifolds, Bianchi identities, geodesics, exponential maps, Chern classes. Other topics as time permits, such as harmonic forms and Hodge's theorem, Jacobi equation, variation of arc length and area, Chern-Gauss-Bonnet theorems. Prerequisite: 11.318.

11.647-648 Homotopy theory
Homotopy groups, fiber spaces, fiber bundles, Hurewicz isomorphism theorem, local coefficients, spectral sequences, cohomology operations, obstruction theory, Postnikov systems. Prerequisite: 11.615-616.
Offered alternate years, alternating with 11.615-616

11.623-624 Topics in Automorphic Functions
11.625-626 Topics in Analysis
11.627-628 Topics in Algebraic Topology
11.631-632 Partial Differential Equations
11.633-634 Topics in Algebraic Number Theory
11.651-652 Topics in Group Representations