The Group program of study offers an interdisciplinary degree. Although the Department of Mathematics, which a student major in logic and the methodology of science who wish to explore the subject in both its mathematical and philosophical aspects. "Methodology of science" is here understood to mean "metascience," the study of the methods of the sciences by logical and mathematical means. The program is administered by an interdepartmental group which cooperates closely with both the Department of Mathematics and the Department of Philosophy.

**Preparation** For admission to the graduate program the student shall have completed an undergraduate major in philosophy, or in mathematics, or a joint major in both, including at least one full year upper division course in logic. In addition, he or she shall have completed (a) at least one full year upper division course in some science, and (b) at least one full year upper division course in mathematics (other than logic) if his or her undergraduate major was philosophy, or in philosophy (other than logic) if his or her undergraduate major was mathematics. Exceptions to these requirements are permitted only at the discretion of the graduate adviser. Before advancement to candidacy, and preferably early in the student's doctoral career, written examinations in two foreign languages must be passed; students may choose from the following: French, German, or Russian. Students should prepare themselves for the language requirement in their undergraduate years.

Further information about the program, including a full statement of the requirements for advancement to candidacy, is given in the ANNOUNCEMENT OF THE GROUP IN LOGIC AND THE METHODOLOGY OF SCIENCE, which is available upon request from the Group Office.

**Courses** Courses are chosen with the advice of the graduate adviser from among the offerings of the various departments of the University. In addition to the departments of Mathematics and Philosophy, attention is especially directed to courses in the various science departments, in statistics, and in linguistics.

**LOGIC AND THE METHODOLOGY OF SCIENCE**

- **Logic Colloquium (1 credit)**
  - Reports on current research and scholarly work by members of the staff, visitors, and graduate students.
  - The staff (J, S, W, S, S, S)

- **Other Departments with Related Programs**
  - Department of Mathematics and Department of Philosophy.

**Undergraduate Programs**

The department offers the undergraduate student a choice of three programs leading to the A.B. degree. The basic major program in mathematics gives the student the opportunity to obtain a strong, well-rounded mathematical background. The faculty of the department is strongly oriented toward research, and courses required for the major are oriented toward theory. For students with particular interests in the applications of mathematics, a special major program in applied mathematics is available.

**General Major Requirements**

Each of the three major programs requires a minimum
of 38 upper division units in the major in addition to a lower division base of 1A-1B-1C, 51A-51B-51C. Courses 111, 190A, 190B, 190C, and 190D are not acceptable toward the upper division major requirements. Additional requirements for these programs are as follows.

**Major in Mathematics 113A-113B; 104A; 104B or 185; 130 or 140 or 142; 135; three additional upper division mathematics courses. Only one of courses 120A and 185 can be offered as part of the major.**

The attention of students interested in logic is directed to Philosophy 12A-12B and Mathematics 152A-152B.

Courses in Computer Science, Physics and Statistics 100A-100B-100C are of interest to mathematics majors.

Subject to the requirements of competence in the major, and with the approval of the major adviser, the student may count not more than two mathematically theoretical courses in computer science, statistics, astronomy, physics, mathematical economics, or other sciences toward his requirements for the major in mathematics.

**Major in Applied Mathematics 120A-120B-120C or three courses from 104A, 104B, 185, 186, 113A and 112, 120A, 128B, 129A or 129B; three additional upper division courses in mathematics or in an applied field (all subject to the approval of the major adviser), of which at least two must be in an applied field.**

**Major in Mathematics for Teachers Philosophy 12A; Statistics 20; 113A-113B-113C, 115A, 130, 132, 134, and 160; one additional upper division mathematics course.**

**Honors Program** In addition to completing the requirements for the major in mathematics or major in applied mathematics, a student in the honors program must (a) earn a grade-point average of at least 3.3 in upper division and graduate courses in mathematics; (b) pass a graduate mathematics course with a grade of at least A–; (c) complete the course H106 in which he will write a senior thesis, or pass a second graduate course with a grade of at least A–; (d) receive the recommendation of his major adviser. Students interested in the honors program should consult with their major adviser at least two quarters before graduation.

**Preparation for Graduate Study** Students preparing for graduate work in mathematics are strongly advised to acquire a reading knowledge of two foreign languages from among French, German, and Russian. This proficiency is required for most Ph.D. programs, but the graduate programs do not leave a large amount of time for language study. There is usually no language requirement for an M.A. degree.

Course 117, designed to challenge the student’s ability to do creative thinking, is useful for students preparing for graduate work. It is also desirable for such students to take some graduate courses while still in undergraduate status; courses 202A–202B–202C, 214, 250A–250B are recommended.

**Graduate Programs**

The department offers the M.A. degree in mathematics and the Cand.Phil. and Ph.D. degrees in both mathematics and applied mathematics. Detailed information concerning admission, teaching assistantships and fellowships, and degree requirements is given in the Graduate Announcement of the Department of Mathematics, which is available upon request from the Graduate Secretary, Department of Mathematics.

**Courses and Seminars**

Courses and seminars are listed below. Statements of instructors commenting on their methods of teaching, emphasis in presenting material, and other characteristics of their courses are posted at the Department Office, 970 Evans, at the beginning of each quarter. Detailed descriptions of seminars and names of instructors offering them are also available.

**Letters and Science List:** For regulations governing this list, see the Announcement of the College of Letters and Science.

**Lower Division Courses**

**P. Algebra and Trigonometry (2)** Four hours of lecture per week. Intended for students who want to take 1A or 1A but lack the prerequisites. A screening test will be given during the pre-enrollment period. May not be used to satisfy the lower division requirement. After receiving credit for 6B, 1A, 1A or the equivalent, students will not receive credit for course P. Review of algebraic graphs, functions, exponential and logarithmic functions, inverse functions. Trigonometric functions and their properties, mathematical induction, binomial theorem, sequences and series. (F, W, Sp)

**1A–1B–1C, Calculus (4–4–4)**

Four hours of lecture per week. Prerequisite: at least three and one-half years of high school mathematics including algebra, geometry, trigonometric and other elementary functions, and some coordinate geometry; student lacking the prerequisites may enroll after completing course F or 6A–6B. A screening test will be given at the first section meeting. This is the usual sequence for students who plan additional study of mathematics. Students who have received credit for 1A or 10A will receive one unit of credit for 1A; students who have received credit for 1B will receive one unit of credit for 1B. Introduction to differential and integral calculus of functions of one variable with applications, transcendental functions, techniques of integration, introduction to differential and integral calculus of several variables. (W, Sp)

Mr. Arveson, Mr. Addison, Mr. Hirsch, Mr. Weintraub, Mr. Vaught (each offered each quarter)

**1S, Self-Paced Study in Introductory Calculus (2–12)**

Four hours of lecture and two to six hours of laboratory per week. Prerequisites: 3½ years of high school mathematics, including algebra, geometry, trigonometric and other elementary functions, and some coordinate geometry. Self-paced instruction covering the material of course 1A–1B–1C. May be repeated for credit up to a total of 12 units. Reduced credit for students who take part of course 1A–1B–1C. Unit credit and grades assigned at the end of the quarter, depending on the number of units studied completed. Mr. Rieffel (F, W, Sp)

**1H–1B–1C, Calculus (5–5–5)**

Five hours per week. Prerequisites: same as 1A plus A’s or B’s in high school mathematics and English, and the consent of students do not receive credit for both 1H and 1B. Honors course corresponding to 1A, 1B, 1C, for also students with strong aptitude. Emphasis on theory, rigor, and proof problems. Recommended as preparation for the major, particularly for honors candidates. Mr. Sarason (sequence beginning F)

**5A, Finite Mathematics (4)** Four hours of lecture per week. Prerequisite: 3 years of high school mathematics, including at least 2 years of high school algebra; course F. A short screening test will be given at the first class meeting. Not open to students who completed 111. Sets, functions, logic, probability, vectors and matrices, with applications. Mr. M. Miller, Mr. Henkis (F, W)

**5B, Finite Mathematics (4)** Four hours of lecture per week. Prerequisite: course 5A or a course in linear algebra. Linear programming, game theory, and combinatory and model theory. Mr. M. Miller (Sp)

**6A–6B, Elementary Mathematical Planning (4–4)**

Three hours of lecture and three hours of laboratory per week. No credit for 6A following courses F, 1A or 1A. A problem-oriented course. Elementary versions of advanced mathematical ideas are studied so as to simultaneously prepare students for calculus and rebuild their high school algebra, geometry, and trigonometry by adding new foundational material and examples from the life, social, and natural sciences. Students with low scores on a placement examination require 1A as a laboratory work. Course 6A alone prepares students for Statistics 9 and Chemistry 1A.

Mr. Rhodes (W)

**10, Mathematics for Liberal Arts Students (4)**

Four hours of lecture per week. Prerequisite: Open to students who have had 1A, 1A, or a more advanced course; but course 10 may be followed by one of the core courses in mathematics for students who have no technical background. Credit in 10 may vary from quarter to quarter. Course 10 is not a remedial course in algebra and trigonometry.

Mr. M. Miller (Sp)

**15, Concepts of Mathematics for Elementary School Teachers (5)**

Five hours of lecture per week. Intended only for prospective elementary school teachers. Restricted to seniors and students in the elementary credential program. No credit for students who have completed 1A or after any other mathematics courses except F, 6A–6B, or 10. Development and structure of the real number system and its subsystems. Elementary concepts of set theory, numeration, factoring and divisibility, nonmetric geometry, measurement. (W, Sp)

**16A–16B, Analytic Geometry and Calculus (4–4)**

Four hours of lecture per week. Prerequisites: two years of high school algebra plus plane trigonometry; students lacking the prerequisites may enroll after completing course F or 6A–6B. A screening test will be given at the first meeting. For students in the social and biological sciences. Course 16A–16B is a terminal course for lower division students whose program does not require more than one year of mathematics. Students who have completed 16A and 190A, or for either 16A or 190A after 1A. After completion of 16A the student may receive credit for both 16A and 16B. They may not receive credit for both 16A and 190C.

16A, Inequalities, absolute value; graphs of simple functions; the derivative; extreme values;
rates of change and differentials; increasing and decreasing functions (mean value theorem); basic properties of log, exp, cos, sin; introduction to integration.

1B. Fundamental theorems of calculus, properties of the integral, integration by substitution and by parts; volumes of solids of revolution and arc length; vector space and linear algebra.

4. Pugh, Mr. Pugh, Mr. Wu (each part offered each quarter)

41. Introduction to Linear Algebra and Vector Analysis

(4-4)

Four hours of lecture per week. Prerequisite: course 115A. Students may not receive credit for both Math 51A or 51B. May not replace Math 51A or 51B as part of the Mathematics Major. Determinants, linear equations, n-dimensional Euclidean space, matrices, linear independence, linear transformations, review of partial differentiation, application of partial differentiation to maximum and minimum problems, multiple integrals and applications, surface and line integrals, Green's theorem, divergence theorem, Stokes' theorem.

51A. Introduction to Linear Algebra.

Four hours of lecture per week. Prerequisite: 1C. Students may not receive credit for both Math 51A and 111. Matrix algebra, simultaneous linear equations, vector spaces, linear transformations, determinants.

M. K. Miller, Mr. DeVore (A-F, W, Sp)

51B. Calculus of Vector Functions.

Four hours of lecture per week. Prerequisite: course 1A and 1B, or consent of instructor. Not open to students who have taken Math 51A. Functions of several variables, multiple integrals and applications, surface and line integrals, Green's theorem, divergence theorem, and Stokes' theorem.

M. K. Miller, Mr. DeVore (A-F, W, Sp)

51C. Differential Equations and Related Topics.

Four hours of lecture per week. Prerequisite: course 1A-B-C. Ordinary differential equations of first and second order, series solutions and higher order equations. An introduction to Fourier series and separation of variables in simple partial differential equations with some applications.

M. K. Miller, Mr. Cordes (A-F, W, Sp)

H51A-H51B-H51C. Linear Algebra, Calculus of Vector Functions, and Differential Equations (S-S-S)

Five hours of lecture per week. Prerequisites: H1C or 1C and consent of instructor. Functions sequence corresponding to A-B-C to S1-A-B-C1 for study with emphasis on applications in mathematics, science, and engineering.

M. Bergman (Sequence beginning F)

Related Courses in Another Department

Computer Science 1. Introduction to Computing.

Pharmacy 12A-12B-12C. Introduction to Logic.


110A-110B. Introductory and Intermediate Analysis.

Three hours of lecture per week. Prerequisite: course 115A. Students may not receive credit for both Math 110A and 110B. Functions, limits, continuity; advanced calculus, functions of several variables, partial derivatives, Jacobian; functions of a complex variable; Riemann surfaces; complex integration; residue theory; analytic continuation and Riemann surfaces.

M. Pugh, Mr. Corder (A-F, W, Sp)

H113A-H113B-H113C. Introduction to Abstract Algebra and Linear Algebra.

Three hours of lecture per week. Prerequisite: course H110A. Students may not receive credit for both Math 113A and 113B. Functions and their inverses, vector spaces, linear independence, linear transformations, determinants, characteristic values, similarity, canonical forms, unitary spaces, unitary similarity, quadratic forms.

M. K. Miller, Mr. Friedman (A-F, W, Sp)

113C. Abstract Linear Algebra.

Three hours of lecture per week. Prerequisite: course 113B. Students may not receive credit for both Math 113A and 113B. Functions and their inverses, vector spaces, linear independence, linear transformations, determinants, characteristic values, similarity, canonical forms, unitary spaces, unitary similarity, quadratic forms.

M. K. Miller, Mr. Friedman (A-F, W, Sp)


Three hours of lecture per week. Prerequisite: courses 110A, 110C, and consent of instructor. Not open to students who have taken Math 110A. Functions sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems. Mr. Wu (Sequences beginning F)

115A. Introduction to Number Theory.

Three hours of lecture per week. Prerequisite: course 110A. Students may not receive credit for both Math 115A and 115B. Topics selected from: Diophantine analysis, continued fractions, partitions, quadratic fields, arithmetic distribution, additive problems, transcendental numbers, and applications to cryptography.

M. Harborth, Mr. Lehman, Mr. DeVore (A-F, W, Sp)

115B. Topics in Number Theory.

Three hours of lecture per week. Prerequisite: course 110A. Students may not receive credit for both Math 115A and 115B. Topics selected from: Diophantine analysis, continued fractions, partitions, quadratic fields, arithmetic distribution, additive problems, transcendental numbers, and applications to cryptography.

M. Harborth, Mr. Lehman, Mr. DeVore (A-F, W, Sp)

115C. Topics in Mathematical Methods Seminar.

Three hours of lecture per week. Prerequisite: consent of instructor. Upper division standing desirable. The student will be required to take a topic suggested by the instructor to try to improve his/her mathematical abilities on problems calling for original thought, and to display methods of attack. Material used may include isolated problems, advanced topics developed through problems, and open-ended research topics. Appropriate for the most part, only mathematical content covered in undergrad courses will be assigned. May be repeated for credit.

M. Bergman (F)

120A-120B-120C. Analysis for Applied Mathematics.

Three hours of lecture per week. Prerequisite: courses 110A or 110B. Students may not receive credit for both Math 120A and 120B. Course sequence corresponding to 110A-110B-110C for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

123A-123B. Mathematical Logic.

Three hours of lecture per week. Prerequisite: courses 110A or 110B. Students may not receive credit for both Math 123A and 123B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

128A. Numerical Analysis.

Three hours of lecture per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 128A and 128B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

128B. Numerical Analysis.

Three hours of lecture per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 128A and 128B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

128C. Computational Algebra.

Three hours of lecture and one hour of problem section per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 128A and 128B. Course sequence corresponding to 110A-110B. Students who wish to prepare for advanced work in applied mathematics should take courses 115B, 115C, 124A, and 185 or 125A-125B-125C.

121A. Orthogonal functions and eigenfunction expansion, Green's functions, applications, special functions of mathematical physics. (F, W)

121B. Partial differential equations: Laplace equation, wave equation, diffusion equation, Green's function. Emphasis on applications of a complete spectral (W, F, Sp)

123A. Ordinary Differential Equations.

Three hours of lecture per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 123A and 123B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems. Mr. Wu (Sequences beginning F)

125A-125B. Mathematical Logic.

Three hours of lecture per week. Prerequisite: courses 110A or 110B. Students may not receive credit for both Math 125A and 125B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

126. Introduction to Partial Differential Equations.

Three hours of lecture per week. Prerequisite: course 110A. Students may not receive credit for both Math 125A and 125B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Bergman (F)

128A. Numerical Analysis.

Three hours of lecture per week and one 4-hour laboratory. Prerequisite: courses 115A and 115B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Lehman (Sp)

128B. Numerical Analysis.

Three hours of lecture per week and one 4-hour laboratory. Prerequisite: courses 115A and 115B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.

M. Lehman (Sp)

128C. Computational Algebra.

Three hours of lecture and one hour of problem section per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 128A and 128B. Course sequence corresponding to 110A-110B. Students who wish to prepare for advanced work in applied mathematics should take courses 115B, 115C, 124A, and 185 or 125A-125B-125C.

121A. Orthogonal functions and eigenfunction expansion, Green's functions, applications, special functions of mathematical physics. (F, W)

121B. Partial differential equations: Laplace equation, wave equation, diffusion equation, Green's function. Emphasis on applications of a complete spectral (W, F, Sp)

123A. Ordinary Differential Equations.

Three hours of lecture per week. Prerequisite: course 110A or 110B. Students may not receive credit for both Math 123A and 123B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems. Mr. Wu (Sequences beginning F)

125A-125B. Mathematical Logic.

Three hours of lecture per week. Prerequisite: courses 110A or 110B. Students may not receive credit for both Math 125A and 125B. Course sequence corresponding to 110A-110B for exceptional students with strong mathematical background and interest. Emphasis is on rigor, depth, and hard problems.
133. Algebraic Curves. (4)
Three hours of lecture per week. Prerequisite: courses 113A, 114A, and consent of instructor. Topics selected from such areas as classical projective geometry, inversive geometry, symplectic geometry, geometric algebra, integral geometry, convexity, and elementary topology. Mr. Seidenberg (W)

134. Number-Systems. (4)
Three hours of lecture per week. Prerequisites: courses 101C, 102A, and 102B. Set-theoretical paradoxes and means of avoiding them. Sets, relations, functions, order and well-order. Proof by transfinite induction and definition by transfinite recursion. Cardinal and ordinal numbers and their arithmetic. Communication of the real numbers. Axiom of choice and its consequences. Mr. Henkin, Mr. Flah (W)

135. Introduction to the Theory of Sets. (4)
Three hours of lecture per week. Prerequisites: courses 113A and 104A. Set-theoretic paradoxes and means of avoiding them. Sets, relations, functions, order and well-order. Proof by transfinite induction and definition by transfinite recursion. Cardinal and ordinal numbers and their arithmetic. Communication of the real numbers. Axiom of choice and its consequences. Mr. Henkin, Mr. Flah (W)

140. Metric Differential Geometry. (4)
Three hours of lecture per week. Prerequisite: courses 104B or 102B. Present formulas, interpretational theorems, inequalities, local theory of surfaces in Euclidean space, first and second fundamental forms, Gaussian and mean curvature, isometries, geodesics, parallelism, the Gauss-Bonnet-Von Dyck Theorem. Mr. Weinberger, Mr. Croft (F, W)

142. Elementary Algebraic Topology. (4)
Three hours of lecture per week. Prerequisites: courses 104A and 113A. The topology of one and two dimensional Euclidean space, fundamental groups, classification of surfaces, Euler characteristic, fundamental groups, plus further topics at the discretion of the instructor. Mr. Chen (W)

145, 104. Boolean Algebras. (4)
Three hours of lecture per week. Prerequisite: course 125A. Postulates, treatment as rings or lattices; relation to relational calculus and calculus of classes; infinite operations, atoms; subalgebras, ideals, direct products; representation theorem.

151. Generalized Functions (Distributions). (4)
Three hours of lecture per week. Prerequisites: courses 104B, 113A, and 113B. Fourier transform, convolution. Differential equations with constant coefficients. Fourier series. Distribution theory. Mr. Silver (F)

160. History of Mathematics. (4)
Three hours of lecture per week. Prerequisites: courses 113A, 113B, and 113D. History of algebra, geometry, and calculus from ancient times through the seventeenth century and related topics from more recent mathematical history. Mr. Silver (F)

163. Tutorial in Upper Division Mathematics. (4)
Four hours per week. Prerequisite: consent of instructor. Emphasis is placed on the individual's experience in discovering and explaining mathematics. Examples of subjects which may be covered are game theory, category theory, differential topology, mathematical foundations of quantum mechanics, global theory of ordinary differential equations, stochastic linear algebra, and number theory. May be repeated for credit with consent of instructor. (Sp)

175. Calculus of Variations. (4)
Three hours of lecture per week. Prerequisites: courses 113B or 114B and 114C. Euler equations for variational problems; differential equations which may be derived from integral principles; solutions of variational problems by direct methods.

180. Introduction to the Theory of Functions of a Complex Variable. (4)
Three hours of lecture per week. Prerequisites: courses 113A and 114A. Set-theoretic paradoxes and means of avoiding them. Sets, relations, functions, order and well-order. Proof by transfinite induction and definition by transfinite recursion. Cardinal and ordinal numbers and their arithmetic. Communication of the real numbers. Axiom of choice and its consequences. Mr. Henkin, Mr. Flah (W)

183. Mathematical Models in Physics and Engineering. (4)
Three hours of lecture per week. Prerequisites: courses 113B and 114B. Designed primarily for mathematics majors with little or no background in physical sciences. Studies the relationship between mathematical models (such as differential and difference equations) and the physical world. Content will vary. Mr. Silver (W)

190A–190B. Survey of Algebra and Analysis. (4–4–4)
Three hours of lecture per week. Prerequisite: upper division or consent of instructor. Survey of algebra and analysis outside mathematics and physical science. Students who have studied calculus should not take 190A but may enter 190B or 190C. Students receive 2 units for 190C following 190B. Course 190D prepares students for course 190A.

190A. Analytic geometry, differential and integral calculus. (F, W)
190B. Calculus of several variables (partial differentiation, extremum problems), complex variables and trigonometry, vectors and vector spaces. (W)
190C. Linear algebra. (F, W)
190D. Differential equations, analysis of several variables, integration, Green's theorem. Application to partial differential equations.

191. Experimental Courses in Mathematics. (4)
The topics to be covered and the method of instruction to be used will be announced at the beginning of each quarter that such courses are offered. May be repeated for credit.

195. Special Topics in Mathematics. (4)
Three hours of lecture per week. Prerequisite: consent of instructor. Lectures on special topics, which will be announced at the beginning of each quarter that the course is offered. May be repeated for credit.

196. Honors Thesis. (4)
Meetings to be arranged. Prerequisite: admission to the Honors Program in Mathematics: a grade-point average of 3.00 overall and a grade-point average of 3.30 in the major. Independent study of an advanced topic leading to an honors thesis. The Staff (F, W, Sp)

199. Supervised Independent Study and Research. (4)
Enrollment is restricted by regulations listed on page 93. Must be taken on a pass or no pass basis.

Related Courses in Other Departments
- Computer Science 167. Graph Theory
- Computer Science 169. Introduction to Combinatorics
- Economics 191A. Introduction to Mathematical Analysis
- Statistics 100A–100B. Introduction to Probability and Statistics
- Statistics 141. Introduction to Continuous Parameter Processes
- Statistics 142. Introduction to Discrete Parameter Stochastic Processes
- Statistics 188. Game Theory

Graduate Courses
- 202A–202B. Introduction to Topology and Analysis. (4–4–4)
- 202A. General topology; theory of topological spaces. (F, W)
- 202C. Measure and integration. The Fourier transform.

203. Measure and Integration. (4)
Three hours of lecture per week. Prerequisite: course 202A (may be taken concurrently). General theory of measure and integration. Lusin's theorem and the Radon-Nikodym theorem.

204A–204B, 204C. Ordinary and Partial Differential Equations. (4–4–4)

205A–205B. Theory of Functions of a Complex Variable. (4)
Three hours of lecture per week. Prerequisite: courses 185 or 190D. General families, the Riemann mapping theorem, Picard's and related theorems, and addition theorems chosen by the instructor from classical complex variable theory.

206A. Linear Spaces. (4)
Three hours of lecture per week. Prerequisites: courses 105 and 185. Functional analysis: Banach and Hilbert spaces, Borel-Banach theorem, closed graph theorem, principle of uniform boundedness, linear operators, weak convergence, spaces $L_p$ and $C$.

206C. Linear Operators. (4)
Three hours of lecture per week. Prerequisites: courses 206A and 202B. Functional analysis: bounded linear functionals and functionals; bounded self-adjoint operators, commutative Banach algebras.

207. Differential Operators. (4)
Three hours of lecture per week. Prerequisite: course 206A. Differential operators, bounded symmetric operators, perturbation theory, additional topics selected by the instructor. Mr. Chalmers (F)

208. Functional Analysis. (4)
Three hours of lecture per week. Prerequisite: course 206A. Locally convex linear topological spaces, distributions, further topics selected by the instructor.

212A–212B. Several Complex Variables. (4–4)
Three hours of lecture per week. Prerequisite: course 205A. Power series and analytic functions of several variables, domains of holomorphic functions, analytic continuation and envelopes of analytic functions, global problems and sheaf theory. Further topics such as pseudoconvexity and the E. Levi problem, embedding theorems for Stein manifolds, hyperbolic theory, normalization theorems, bounded domains in $C^n$. (W)

214. Differential Manifolds. (4)
(Formerly numbered 505A.) Three hours of lecture per week. Prerequisite:
261A, 261B, 261C. Lie Groups. (4-4-4) Three hours of lecture per week. Prerequisite: course 214 Lie groups and Lie algebras, general structure of connected, solvable, simple, and semi-simple groups; classification of simple groups, representation theory; further topics such as the theory of symmetric spaces. Mr. Hochschild (Sequence beginning Fall).

265. Differential Topology. (4) Three hours of lecture per week. Prerequisite: course 214. Vector bundles, tubular neighborhoods, approximation theorems, Morse theory, handlebodies, surgery and cobordisms. Mr. Hirsch (Sp).

270. Mathematical Theory of Fluid Dynamics. (4) Three hours of lecture per week. Development of the fundamental equations describing the behavior of fluids. Continuation followed by the treatment of special topics selected to exhibit different physical situations, analytical techniques and approximate methods of solution. Mr. Chorin (Sp).

271. Topics in Foundations. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. Addisen (F), Mr. Silver (W).

272. Topics in Differential Topology. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit.

273. Topics in Advanced Numerical Analysis. (4) (Formerly 229C) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, hence it may be repeated for credit.

274. Topics in Algebra. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. Hartshorne (F), Mr. Bergman (W), Mr. Glog (Sp).

275. Topics in Applied Mathematics. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. F. Cate (W).

276. Topics in Topology. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. Stallings (Sp).

277. Topics in Differential Geometry. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. Weinstein (Sp).

278. Topics in Analysis. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit. Mr. Arveson (F), Mr. Kac (W), Mr. Rieffel (Sp).

279. Topics in Partial Differential Equations. (4) Three hours of lecture per week. Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. Hence it may be repeated for credit.

280A, 280B, 280C. Mathematical Theory of Relativity. (4) Three hours of lecture per week. Prerequisite: course 140 or consent of instructor. Special theory of relativity, spinor representation of the Lorentz group, reformulation of classical physical theories in relativistic form, principles of equivalence, Einstein theory of gravitation, cosmological problems.

290. Seminars. (2-4) One 2-hour lecture per week. Credit and grades will be awarded at termination of seminar. Topics in foundations of mathematics, theory of numbers, functional analysis, arithmetic geometry, algebra, and their applications, by means of lectures and informal conferences, work based largely on original memoirs.

295. Individual Research. (2-8) By appointment. Intended for candidates for the Ph.D. degree. Sections 1-50 must be taken on a letter grade basis. Sections 51-60 must be taken on a satisfactory/unsatisfactory basis. The Staff (W, F, Sp).

299. Reading Course for Graduate Students. (2-8) By appointment. Investigation of special problems under the direction of members of the department. Sections 1-50 must be taken on a letter grade basis. Sections 51-60 must be taken on a satisfactory/unsatisfactory basis. The Staff (W, F, Sp).

300. Teaching Workshop. (3) Three to four hours of lecture per week. Designed for new teaching assistants in mathematics. The course consists of microteaching sessions for the development of elementary teaching skills, lesson planning and alternatives to standard classroom methods, a program of guided group and self-analysis, and a schedule of reciprocal classroom visits. Must be taken on a pass/fail basis. Mr. Laws (F).

601. Individual Study for Master's Students. (1-4) Individual study for the comprehensive or language requirements in consultation with the field advisor. Units may not be used for the master's degree. The Staff (W, F).

602. Individual Study for Doctoral Students. (1-4) Individual study in consultation with the major field advisor. The Staff (W, F).

105. 7. Self-Paced Study in Introductory Physics and Calculus. (1-12) Mr. Steen (W).

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Statistics 262. Information Theory.
Related Programs
Computer Science See Department of Electrical Engineering and Computer Sciences, Computer Science Division.
Logic See Group in Logic and the Methodology of Science and Department of Philosophy.
Mathematics Education See Group in Science and Mathematics Education.
Statistics See Department of Statistics.

MEDICAL PHYSICS

(Division Office, 103 Donner Laboratory)

Professors:
Hans J. Bremermann, Ph.D.
Harold B. Price, Ph.D.
Robert K. Mortimer, Ph.D. (Chairman)
Alexander V. Nichols, Ph.D.
Cornelius A. Tobias, Jr., Ph.D.
John W. Coffman, M.D., Ph.D. (Emeritus)
Thomas H. Jukes, Ph.D., D.Sc. (in Residence) (Emeritus)
John H. Lawrence, M.D., Sc.D. (Emeritus)
John H. Northrop, Ph.D., Sc.D., LL.D. (Emeritus)

Associate Professors:
Robert M. Gleason, Ph.D.
Howard C. Mcl., Ph.D.

Assistant Professor:
H. John Burk, Ph.D.

Professors:
Thomas L. Hayes, Ph.D. (Adjunct)
A. Douglas McLaren, Jr., Ph.D.

Associate Professor:
Alan J. Bearden, Ph.D. (Adjunct)

Undergraduate Advisers: Mr. Bearden, Mr. Gleason, Mr. Nichols.

The courses of the division are designed to meet several objectives: (1) to prepare students for advanced work in biophysics, medical physics, and allied fields; (2) to offer for physical science and engineering students selected topics and concepts of the physical sciences; and (3) to provide biomedical oriented students an introduction to those sciences and to some of the quantitative physical problems and approaches in biology and medicine. Courses 10, 11, and 103 are designed to provide background and perspective in their specified fields.

Individual Major in Biophysics

An individual major in biophysics (physics and biology) may be arranged in consultation with one of the major advisers. Lower division courses in physics, science with one of the major advisers. Recommended courses include atomic and molecular physics, and biology. In addition, 45 units of upper division courses in physics and chemistry, and biology, are required as preparation for the major. In mathematics and biology are required as preparation for the major. In addition, the major adviser may include atomic and molecular physics, and biology. Additional courses include atomic and molecular physics, and biology.

Note: For key to footnote symbols, see page 92.