Berkeley '85-'86

3. Anthropology 3, Economics 1, Psychology 1, Sociology 1 or Sociology 3;

4. Mass Communications 10.

These courses must be completed (or enrolled in) when applying for admission to the major.

**Requirements for Graduation** (in addition to the prerequisites for admission to the major).

A. The following three core courses in mass communication: Mass Communications 101; Mass Communications 102; Mass Communications 103.

B. One of the following methods courses or sequences: Anthropology 190A + lab-190B + lab; Political Science 3; Political Science 132A; Political Science 132B; Political Science 133; Psychology 101; Sociology 5; Sociology 105.

C. Five or six different courses from the following list. *No student may count toward the major more than three courses offered outside the College of Letters and Science.* Anthropology 144, Anthropology 149, Anthropology 165, Anthropology 166, Business Administration 165, Business Administration 169, English 173, English 176, Journalism 140, Journalism 141, Journalism 163, Journalism 165, Linguistics 150, Political Science 161, Political Science 164A, Political Science 164B, Political Science 168A-168B, Psychology 123, Psychology 124, Psychology 160, Psychology 162, Psychology 165, Psychology 168, Sociology 110, Sociology 140, Sociology 160, Sociology 170.

Any exceptions or substitutions must be approved by the major adviser.

The College of Letters and Science requires that *30 upper division units* be completed in the major. Students who have used an *upper division* History or Political Science course to satisfy the prerequisites, or who have used an *upper division* course to satisfy the methods requirement, will normally satisfy this 30 unit requirement by taking *five* courses from the elective list (C, above). Students who have used lower division courses to satisfy these requirements will normally need to take *six* courses from the elective list to total 30 upper division units in the major.

**Honors Program.** To be admitted to the honors program, a student must have attained at least a 3.3 grade-point overall in the University and a 3.3 grade-point average in the major. In order to be granted honors, a student must write a thesis which in the judgment of the thesis director and the adviser is characterized by superior distinction. An honor student must also complete Mass Communications H195, a one semester honors colloquium.

*Lower Division Courses*

**10. Mass Communications in America: An Introduction. (4).** *Formerly 10.* Two 1½-hour lectures plus two 1-hour sections per week. *Prerequisites: Sophomore standing or permission of the instructor.* An introduction to the history, functions, and control of mass communication institutions in the United States, and to media content and effects. (F) *Hansen*

**11. Mass Communications in America: An Introduction. (4).** Two 2-hour seminars per week. An introduction to the process of mass communication, including: 1) the role of mass media; 2) basic theories of communication; 3) components of the communication process; 4) media as professional environments; 5) interpersonal and mass communication compared; 6) the potential impact of new technologies. (SP) Not offered 1985-86.

*Upper Division Courses*

**101. The Structure of Mass Communications. (4).** *Formerly 101.* Two 1½-hour lectures plus two 1-hour sections per week. *Prerequisites: 10 and sophomore standing, or permission of the instructor.* Analysis of contemporary structures of mass communications, primarily in capitalist societies, with historical background on the popular press, radio and television. The organization of news and entertainment. Comparison with other societies. (SP) *Gitlin*

**102. The Effects of the Mass Media. (4).** *Formerly 102.* Two 1½-hour lectures plus two 1-hour sections per week. *Prerequisites: 10, or permission of the instructor.* Introduction to the study of communication effects, alternative analytic models, the effects of television, and the effects of mass media exposure on attitude change. (F) *Jackson*

**103. The Communications Media in Public Policy. (4).** *Formerly 103.* Two 1½-hour lectures plus two 1-hour sections per week. *Prerequisites: 10 or permission of the instructor.* The context for policy affecting the communications media, including legal constraints, governmental institutions, media interests and public interest groups. Effects of the media (e.g., the violence issue and portrayal of special population groups) will be assessed. Other current policy issues (e.g., special privileges for journalists and interactive cable TV) will be examined. (SP) *Tannenbaum*

**H195. Honors Colloquium. (3).** *Formerly H195A-195B.* One 3-hour seminar per week. *Prerequisites: Open only to honors seniors in the group major in Mass Communications.* Under the supervision of the instructor, students will work toward preparing scholarly theses in the field, basing their work on theoretical considerations and, where applicable, analyzing empirical data. (SP) *Staff*

**197A. Media and Society. (4).** *Formerly 197.* One 3-hour seminar plus ten to twelve hours field laboratory per week. *Prerequisites: Consent of instructor required.* Analysis of contemporary media in terms of access, social organization and impact. Seminar topics: audience, objectivity, ownership and control; content and content analysis; alternative media; ethics and law; professionalization; advertising. Field placements: national and local news magazines; television and radio stations; newspapers. (F) *Miner*

**197B. Social Issues in Publishing. (4).** *Formerly Field Studies 196Q-196R.* One 3-hour seminar and ten to twelve hours of field laboratory per week. *Prerequisites: Consent of instructor required.* Discussion of communications and language; tastes, values and standards; local culture; the economics of production and consumption; development and socialization of culture. Seminar topics include: literacy; acquisition of manuscripts; whence western publishing; publishing profession versus the book industry; first amendment/publishers' rights and responsibilities. Field placements include: literary agencies; bookstores; critical reviews; publishers. (SP) *Miner*

**198. Directed Group Study for Advanced Undergraduates. (1-4).** *Formerly 198.* Course may be repeated for credit. Must be taken on a *passed/not passed* basis. *Prerequisites: Regulations set by College of Letters and Science.* Seminars for the group study of selected topics not covered by regularly schedule courses. Topics will vary from year to year. (F,SP) *Staff*

**199. Supervised Independent Study for Advanced Undergraduates. (1-4).** *Formerly 199.* Course may be repeated for credit. Must be taken on a *passed/not passed* basis. *Prerequisites: Regulations set by College of Letters and Science.* Independent study and research by arrangement with faculty. (F,SP) *Staff*

# Mathematics

**Department Office, 970 Evans Hall, 642-6550**

**Professors:**

John W. Addison Jr., Ph.D.
William B. Arveson, Ph.D.
William G. Bade, Ph.D.
George M. Bergman,[1] Ph.D.
Elwyn R. Berlekamp,[1] Ph.D.
David Blackwell, Ph.D.
Hans J. Bremermann, Ph.D.
Paul L. Chambre, Ph.D.
Paul R. Chernoff,[1] Ph.D.
Alexandre J. Chorin, Ph.D.
Heinz O. Cordes, Ph.D.
Gerard Debreu, D.Sc.
Rene J. De Vogelaere. Ph.D.
Stephen P. Diliberto, Ph.D.
Lester E. Dubins,[3] Ph.D.
Jacob Feldman, Ph.D.
David A. Freedman, Ph.D.
David Gale, Ph.D.
David M. Goldschmidt,[2] Ph.D.
F. Alberto Grunbaum, Ph.D.
Ole H. Hald,[1] Ph.D.
Leo A. Harrington, Ph.D.
Robert C. Hartshorne, Ph.D.
Henry Helson, Ph.D.
Leon A. Henkin, Ph.D. *(Chair)*
Morris W. Hirsch, Ph.D.
Wu-Yi Hsiang, Ph.D.
William Kahan,[3] Ph.D.
Irving Kaplansky, Ph.D.
Richard M. Karp, Ph.D.
Tosio Kato, D.Sc.
Robion D. Kirby Ph.D.
Michael Klass, Ph.D.
Shoshichi Kobayashi, Ph.D.
Tsit-Yuen Lam, Ph.D.
Oscar E. Lanford, III, Ph.D.
Lucien Le Cam, Ph.D.
R. Sherman Lehman, Ph.D.
Andrew J. Majda,[1] Ph.D.
Jerrold E. Marsden, Ph.D.
Ralph N. McKenzie, Ph.D.
Keith Miller, Ph.D.
Calvin C. Moore, Ph.D.
Arthur Ogus, Ph.D.
Andrew P. Ogg, Ph.D.
Beresford N. Parlett, Ph.D.
Edmund J. Pinney, Ph.D.
Murray H. Protter, Ph.D.
Charles C. Pugh, Ph.D.
Marina Ratner, Ph.D.
John L. Rhodes, Ph.D.
Kenneth A. Ribet, Ph.D.
Marc A. Rieffel, Ph.D.
Maxwell A. Rosenlicht,[2] Ph.D.
Rainer K. Sachs, Ph.D.
Donald E. Sarason, Ph.D.
Richard R. Schoen,[1] Ph.D.
Abraham Seidenberg, Ph.D.
Jack H. Silver, Ph.D.
Isadore Singer,[1] Ph.D.
Stephen Smale,[1] Ph.D.
Robert M. Solovay, Ph.D.
Edwin H. Spanier,[1] Ph.D.
John R. Stallings, Jr.,[3] Ph.D.
P. Emery Thomas, Ph.D.
Robert L. Vaught, Ph.D.
John B. Wagoner, Ph.D.
Alan D. Weinstein, Ph.D.
Joseph A. Wolf, Ph.D.
Hung-Hsi Wu,[1] Ph.D.
Shiing-Shen Chern, D.Sc., LL.D. *(Emeritus)*
Alfred L. Foster, Ph.D. *(Emeritus)*
Gerhard P. Hochschild,[1] Ph.D. *(Emeritus)*
John L. Kelley,[1] Ph.D. *(Emeritus)*
Derrick H. Lehmer, Ph.D. *(Emeritus)*
Hans Lewy, Ph.D. *(Emeritus)*
Julia Robinson,[1] Ph.D. *(Emeritus)*
Raphael M. Robinson, Ph.D. *(Emeritus)*
Ichiro Satake, Ph.D. *(Emeritus)*
Abraham H. Taub, Ph.D. *(Emeritus)*
Angus E. Taylor, Ph.D. *(Emeritus)*
Frantisek Wolf, Ph.D. *(Emeritus)*

**Associate Professor:**

Robert M. Anderson, Ph.D.

**Acting Associate Professor:**

Clifford Taubes, Ph.D.

**Assistant Professors:**

Robert F. Coleman, Ph.D.
Jenny C. Harrison, Ph.D.
John C. Neu, Ph.D.

**Adjunct Professor:**

Paul Concus, Ph.D.

**Visiting Lecturers:**

Shahla Marvizi, Ph.D.
Alice Roos, Ph.D.
Aaron Fogelson, Ph.D.

## Undergraduate Programs

The department offers the undergraduate student a choice of two programs leading to the A.B. degree: the major in mathematics and the major in applied mathematics. Each major program in mathematics gives the student the opportunity to obtain a strong, well-rounded mathematical background, suitable for post-graduate study as well as for professional careers in science, industry, or education. The courses required for the major emphasize theoretical material. Students with an interest in the applications of mathematics may find the major program in applied mathematics particularly responsive to their needs.

**General Major Requirements.** Both major programs require a lower division base of Mathematics 1A-1B and 50A-50B. Courses 16A-16B are not an acceptable alternative. The minimum upper division major requirements are as follows:

**Major in Mathematics.** (a) Courses 104, 185, 113A, 113B (b) One course from each of two of the following three subject areas: I. Computing (100, 128A) II. Geometry (140, 141, 142) III. Logic and foundations (125A, 135) (c) At least eight upper division courses in all.

With the approval of the major adviser, students may count not more than two mathematically theoretical courses in computer science, statistics, physics, astronomy, mathematical economics, or other sciences toward requirements for the major in mathematics.

**Major in Applied Mathematics.** (a) 104, 113A, 185 (b) 112 or 113B, and 128A (c) 3 additional upper division courses, approved by a major adviser, which make a coherent cluster in some applied area such as: Actuarial Science, Classical Mechanics, Computer Science, Decision Theory, Economics, Fluid Mechanics, Geophysics, Mathematical Biology, Numerical Analysis, Operations Research, Probability Theory, Systems Theory. Many other clusters are also available.

**Honors Program.** In addition to completing the requirements for the major in mathematics or major in applied mathematics, students in the honors program must (a) earn a grade-point average of at

least 3.5 in upper division and graduate courses in mathematics and at least 3.3 in all courses taken in the University; (b) complete course 196 in which they will write a senior honors thesis, or pass two graduate mathematics courses with a grade of at least A-; (c) receive the recommendation of their major adviser. Students interested in the honors program should consult with their major adviser at least two semesters 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. Course H117, designed to challenge the student's ability to do creative thinking, is useful for students preparing for graduate work. Undergraduate students also often take one or more of the following introductory graduate courses: 202A-202B, 214, 228A-228B, 250A-250B.

*Lower Division Courses*

**P. Algebra and Trigonometry. (2).** *Formerly P.* No credit will be given to students who take Math P after completing any other course in the department with the exception of Math 10. Two 1-hour lectures and two 1-hour sections per week. *Prerequisites: Two years of high school math, plus a satisfactory grade in either the CEEB MAT test or the UC/CSU math diagnostic test. Consult the Math department for details.* A review of algebra, graphs, functions, exponential and logarithmic functions, trigonometry, inverse functions, complex numbers, binomial theorem and conics. Designed for students who wish to prepare for calculus. Two units recorded credit, but recognized as four units of work in computing study lists. (F,SP) *Staff*

**PS. Algebra and Trigonometry. (1-2).** *Formerly PS.* One or two units recorded credit, but recognized as two or four units of workload in computing study lists. No credit will be given to students who take Math PS after completing any other course in the Math department, with the exception of Math 10. Open consulting. *Prerequisites: Two years of high school math.* A self-paced version of Mathematics P. Students are strongly urged to enroll in only one unit; units of credit can be adjusted upward at the end of the semester, depending on the amount of work completed. (F,SP) *Bergman*

**1A-1B. Calculus. (4;4).** *Formerly 1A-1B-1C.* Students will receive no credit for 1A or 1B after taking 2A or 3; 2 units for 1A after 16A, no credit for 1A after 16B, and 2 units for 1B after 16B.Two 1-hour lectures and two 1-hour sections per week. *Prerequisites: Three and one half years of high school math, including trigonometry and analytic geometry plus a satisfactory grade in one of the following: CEEB MAT test; an AP test; the CSU math diagnostic test; or Math P. Consult the Math Department for details. Students with AP credit should consider choosing a course more advanced than 1A.* An introduction to differential and integral calculus of functions of one variable with applications, transcendental functions, techniques of integration, introduction to differential equations and infinite series, vectors, and introduction to differential and integral calculus of several variables. This is intended for majors in engineering and natural sciences. Some lecture sections may have a third lecture hour weekly and/or some workshops; these would not cover new material and student attendance would be strictly optional. (F,SP)
*Wu, Goldschmidt, Ribet, Ogus, Harrison, Rosenlicht, Thomas*

**1AS-1BS. Self-Paced Study in Calculus. (1-4;1-4).** Students will receive no credit for 1AS-1BS after taking 2A or 3. Open consulting. *Prerequisites: Same as 1A-1B. Formerly 1AS-1BS-1CS.* A self-paced version of Mathematics 1A-1B. Reduced credit for students who have taken part(s) of 1A-1B-1C or 16A-16B. Simultaneous enrollment in both sections is possible. Unit credit and grades assigned at the end of each semester, depending on the number of study units completed. Units of credit can be adjusted upward. (F,SP)
*McKenzie*

**H1A-H1B. Analytic Geometry and Calculus. (5;5).** *Formerly H1A-H1B-H1C.* Credit restrictions the same as for 1A-1B. Three 1-hour lectures and two 1-hour sections per week. *Prerequisites: Same as 1A-1B, plus As and Bs in high school math.* Honors course corresponding to 1A-1B for able students with strong mathematical inclination and motivation. Emphasis on theory, rigor, and hard problems. Recommended as preparation for the major, particularly for honors candidates. (F,SP) *Staff*

**2A-2B. Introduction to Analysis and Applied Calculus. (6;6).** *Formerly 2A-2B.* Students will receive no credit for 2A after taking 1B or 3 and no credit will be given for 2B after completion of 50B. Three 1-hour lectures and three 1-hour sections per week. *Prerequisites: Three and one-half years of high school math, including trigonometry and analytic geometry.* Math 2A-2B covers all the material of Math 1A-1B and 50A-50B in one instead of the normal two years. This is intended for the engineers and science majors who wish to complete the math prerequisites in one year. Students considering a major in Math who wish to substitute this sequence for 1A-1B and 50A-50B should consult with the department first. (F,SP) *Diliberto*

**3. Accelerated Freshman Calculus. (5).** Students will receive no credit for 3 after taking 1B or 2A. Three 1-hour lectures and two 1-hour sections weekly. *Prerequisites: One year of high school calculus, or consent of instructor.* Covers the material of Math 1A-1B in one semester. The material of Math 1A is reviewed. Most of the time is spent on 1B material. (F) *Pugh*

**10. Mathematics for Liberal Arts Students. (3).** *Formerly 10.* Three hours of lecture per week. Concepts of modern mathematics for students with no technical background. The topics vary from semester to semester. The instructor in charge will announce the topics each semester. This is not a remedial class in algebra and/or trigonometry. Not offered 1985-86.

**15. Concepts of Mathematics for Elementary School Teachers. (3).** *Formerly 15.* Three hours of lecture per week. *Prerequisites: Senior standing and admission to the elementary credential program.* Development and structure of the real number system and its subsystems. Elementary concepts of set theory, numeration, factoring and divisibility, nonmetric geometry, measurement. Not offered 1985–86.

**16A-16B. Analytic Geometry and Calculus. (3;3).** *Formerly 16A-16B.* Students will receive no credit for 16A after taking 1A or 190A, no credit for 16B after 1B, 2A, 3, or 190B, and 2 units for 16B after 1A. Two 1-hour lectures and one 1-hour section per week; possible third hour of lecture or workshop. *Prerequisites: Two years of high school math, including trigonometry, plus a satisfactory grade in one of the following: CEEB MAT test, an AP test, the UC/CSU math diagnostic test, or Math P. Consult the Math Department for details.* Inequalities, absolute value, graphs of simple functions, the derivative, maxima and minima, rates of change and differentials, increasing and decreasing functions, basic properties of log, exp, cos, sin, introduction to integration, fundamental theorem of calculus, properties of the integral, integration by substitution and by parts, volumes of solids of revolution and arc lengths. (F,SP) *Lam, Chorin, Gale, Smale, Lashoy, Spanier*

**16AS-16BS. Self-Paced Study in Analytic Geometry and Calculus. (1-3;1-3).** Unit credit and grades assigned at the end of each semester, depending on the number of study units completed. Units of credit can be adjusted upward.Open consulting. *Prerequisites: Same as 16A-16B. Formerly 16AS-16BS.* Self-paced instruction covering the material of 16A-16B. Reduced credit for students who have taken part(s) of 1A-1B-1C or 16A-16B. Simultaneous enrollment in both sections is possible. (F,SP) *Klass*

**49. Supplementary Work in Lower Division Mathematics. (1-3).** Course may be repeated for credit. Meetings to be arranged. *Prerequisites: Some units in a lower division Mathematics class.* Students with partial credit in lower division mathematics courses may, with consent of instructor, complete the credit under this heading. (F,SP) *Staff*

**50A. Sophomore Mathematics. (4).** *Formerly a portion of the 50A-50B-50C series.*Three 1-hour lectures and two 1-hour sections per week. *Prerequisites: 1B or 2A or 3.* Ordinary differential equations. Basic linear algebra. Introduction to partial differential equations; Fourier series. (F,SP) *Sarason, Marsden, Feldman, Silse*

**50B. Sophomore Mathematics. (4).** *Formerly a portion of the 50A-50B-50C series.*Three 1-hour lectures and two 1-hour sections per week. *Prerequisites: 50A.* Multivariable calculus: gradient, divergence and curl; multiple intergrals; Green's, Stokes', and Gauss' Theorems. Applications of linear algebra to multivariable calculus. Eigenvalue problems. (F,SP)
*Helson, Miller, Spanier, Marsden, Henkin*

**H50A-H50B. Honors Sophomore Mathematics. (4;4).** *Formerly H50A-50B-50C.* Three 1-hour lectures and two 1-hour sections per week. *Prerequisites: Same as 50A-50B.* This is the honors class corresponding to 50A-50B. There is greater emphasis on theory and challenging problems; the material is rearranged in a more logical order. Recommended for students who enjoy mathematics. (F,SP) *Neu, Jones*

**51. Introduction to Linear Algebra. (3).** *Formerly 51.* Students will receive no credit for 51 after taking 50B. Two 1-hour lectures and two 1-hour sections per week. *Prerequisites: 1B, 2A, 3, or 16B.* Matrix algebra, simultaneous linear equations, vector spaces, linear transformations, determinants, eigenvectors. (SP)
*Rhodes*

**55. Discrete Mathematics. (3).** *Formerly 55.* Two 1-hour lectures and two 1-hour sections per week. *Prerequisites: 1B, 3, or 16B.* Logic, mathematical induction, finite series, sets, relations, and functions, introduction to trees, combinatorics, algebraic structures, probability. Emphasis on topics of interest to students of computer science. (F,SP) *Wolf, Gale*

*Upper Division Courses*

**100. Computational Mathematics. (3).** *Formerly 115M and 116.*Course may be repeated for credit if approved by the Mathematics Adviser. Two 1-hour lectures and one 3-hour laboratory per week. *Prerequisites: Vary according to instructor.* Syntactic and semantic description of a higher level language. Exploration and application to more than one branch of Mathematics among group theory, number theory, systems of ordinary differential equations, complex analysis, geometry. Prerequisites and specific topics will vary. (SP)
*DeVogelaere*

**IDS 103. Introduction to Mathematical Economics. See IDS courses at end of Mathematics course listings.**

**104. Introductory and Intermediate Analysis. (4).** *Formerly 104A and a portion of 104B.* Three 1-hour lectures per week. *Prerequisites: 50B or 2B. This course requires at least 12 hours per week of effort including time spent in class and in outside reading and preparation.* A review of single variable calculus; the topology of $R^n$; metric spaces; uniform convergence; Frechet derivative and chain rules; implicit function theorems; existence of solutions of ODEs by fixed point theorems; series; integration. (F,SP) *Harrison, Pinney, Protter*

**H104. Introductory and Intermediate Analysis. (4).** *Formerly H104.* Three 1-hour lectures per week. *Prerequisites: 50B or 2B. This course requires at least 12 hours per week of effort, including time spent in class and in outside reading and preparation.* Same as 104. Recommended for students who enjoy mathematics and are good at it. Greater emphasis on theory and challenging problems. (F) *Jones*

**105. Integration. (3).** *Formerly 105.* Three 1-hour lectures per week. *Prerequisites: 104.* Null sets and the Riemann integral, construction and properties of Lebesgue measure, the Lebesgue integral and convergence theorems, Fubini's theorem, absolutely continuous functions and differentiation, completeness, and Fourier series. (SP) *Rosenlicht*

**112. Linear Algebra. (3).** *Formerly 112.* Three 1-hour lectures per week. Some, but not all, sections may also have a one-hour discussion section. *Prerequisites: 51, 50B, or 111.* For students in engineering or mathematical, natural, or social sciences. The course is oriented more toward a concrete knowledge of matrix theory than is 113B. Characteristic equations, values and vectors; orthogonal and unitary vector spaces, orthogonal, unitary, and hermitian matrices; quadratic forms, hermitian forms, and diagonalization of normal matrices; introduction to infinite-dimensional spaces. (F,SP)
*Lehman, Harrison, Feldman*

Note: For key to symbols, see page 48.

Berkeley '85-'86

**113A-113B. Introduction to Abstract Algebra. (4;4).** *Formerly 113A-113B-113C.* Three 1-hour lectures per week. *Prerequisites: 50B, 51 or 111. This course requires at least 12 hours per week of effort, including time spent in class and in outside reading and preparation.* Sets, groups, rings, fields, polynomials. Vector spaces, linear transformations and matrices, dual vector spaces, determinants, characteristic values, similarity, canonical forms, unitary spaces, unitary similarity, quadratic forms. (F,SP) *Rhodes, Lehman, De Vogelaere*

**H113A-H113B. Introduction to Abstract Algebra. (4;4).** *Formerly H113A-113B.* Three 1-hour lectures per week. *Prerequisites: Same as 113A-113B.* Honors version of 113A-113B. This course requires at least twelve hours per week of effort including time spent in class and in outside reading and preparation. (F,SP) *Coleman, Staff*

**115. Introduction to Number Theory. (3).** *Formerly 115.* Three 1-hour lectures per week. *Prerequisites: 50B, 51 or 111.* Divisibility, congruences, numerical functions, theory of primes. Topics selected: Diophantine analysis, continued fractions, partitions, quadratic fields, asymptotic distributions, additive problems. (F,SP) *Kobayashi, Lehman*

**H117. Mathematical Problem Seminar. (3).** *Formerly H117.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Recommended for exceptional students with strong mathematical background and interest. Problems calling for original thought and various mathematical approaches. May include advanced topics developed through problems and open research problems. Not offered 1985–86.

**120A-120B. Analysis for Applied Mathematics. (3;3).** *Formerly 120A-120B-120C.* Three 1-hour lectures per week. *Prerequisites: 50B or 2B.* Sets, sequences and series. Theory of functions of a complex variable; continuity, differentiability, and Riemann integration. Singularities, analytic continuation, and Riemann surfaces. Residue theory. Ordinary differential equations. Sturm-Liouville problems. Special functions and partial differential equations of mathematical physics. Conformal mapping. Contour integration. Holmorphic functions. Cauchy theory. Laurent series. Improper integrals. Gamma functions. (F,SP) *Kato, Pinney*

**121A-121B. Mathematical Tools for the Physical Sciences. (3;3).** *Formerly 121A-121B-121C.* Three 1-hour lectures per week. *Prerequisites: 50B or 2B.* Functions of a complex variable, Fourier series finite-dimensional linear systems, introduction to infinite-dimensional systems. Infinite dimensional linear systems, orthogonal expansions, special functions, partial differential equations arising in mathematical physics. Similar to 104 and 185 or 120A-120B, but with more emphasis on applications. (F,SP) *Chernoff, Staff*

**123. Ordinary Differential Equations. (3).** *Formerly 123.* Three 1-hour lectures per week. *Prerequisites: 104.* Existence and uniqueness of solutions, linear systems, regular singular points. Other topics selected from analytic systems, autonomous systems, Sturm-Liouville Theory. (F) *Neu*

**125A-125B. Mathematical Logic. (3;3).** *Formerly 125A-125B.* Three 1-hour lectures per week. *Prerequisites: 113A or consent of instructor.* Sentential and quantificational logic. Formal grammar, semantical interpretation, formal deduction, and their interrelation. Applications to formalized mathematical theories. Selected topics from model theory or proof theory. (F,SP) *Addison, Vaught*

**126. Introduction to Partial Differential Equations. (3).** *Formerly 126.* Three 1-hour lectures per week. *Prerequisites: 104.* Classification of second order equations, boundary value problems for elliptic and parabolic equations, initial value problems for hyperbolic equations, existence and uniqueness theorems in simple cases, maximum principles, *a priori* bounds, the Fourier transform. (SP) *Chorin*

**128A. Numerical Analysis. (4).** *Formerly 128A.* Three 1-hour lectures plus one 3-hour laboratory per week. *Prerequisites: 50B.* Programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations. Direct solutions of systems of linear equations. Practice on the computer. (F,SP) *Cordes, Dillberto, DeVogelaere, Berlekamp, Solovay*

**128B. Numerical Analysis. (4).** *Formerly 128B.* Three or four 1-hour lectures according to the instructor plus one 3-hour laboratory per week. *Prerequisites: 128A and 112.* Iterative solution of systems of linear equations, evaluation of eigenvalues and eigenvectors of matrics, applications to simple partial differential equations. Practice on the computer. (F,SP) *Kahan, di Perna*

**130. The Classical Geometrics. (3).** *Formerly 130.* Three 1-hour lectures per week. *Prerequisites: 113B.* Topics chosen from the following list: axioms for affine and projective planes, planes over a division ring, duality, the coordinatization theorem, n-dimensional projective geometry over a field, collineations and correlations, classification of hyperquadrics, the projective group and its sub-groups, non-Euclidean geometry, inversive geometry. Not offered 1985–86.

**132. Topics in Geometry. (4).** *Formerly 132.* Three 1-hour lectures per week. *Prerequisites: 104 and 113A, or consent of instructor.* Topics selected from such areas as classical projective geometry, inversive geometry, symplectic geometry, geometric algebra, integral geometry, convexity, and elementary topology. (F) *Dubins*

**135. Introduction to the Theory of Sets. (3).** *Formerly 135.* Three 1-hour lectures per week. *Prerequisites: 113A and 104.* Set-theoretical paradoxes and means of avoiding them. Sets, relations, functions, order and well-order. Proof by transfinite induction and definitions by transfinite recursion. Cardinal and ordinal numbers and their arithmetic. Construction of the real numbers. Axiom of choice and its consequences. (F,SP) *Addison, Rosenlicht*

**H135. Introduction to the Theory of Sets.. (3).** *Formerly H135.* Three 1-hour lectures per week. *Prerequisites: 113A and 104.* Honors section corresponding to course 135 for exceptional students with strong mathematical inclination and motivation. Emphasis is on rigor, depth, and hard problems. Not offered 1985–86.

**140. Metric Differential Geometry. (3).** *Formerly 140.* Three 1-hour lectures per week. *Prerequisites: 104 or 120B or 121B.* Frenet formulas, isoperimetric inequality, 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. (F,SP) *Rieffel, Kirby*

**141. Elementary Differential Topology. (3).** *Formerly 141.* Three 1-hour lectures per week. *Prerequisites: 104 or equivalent and linear algebra.* Manifolds in n-dimensional Euclidean space and smooth maps, Sard's Theorem, classification of compact one-manifolds, transversality and intersection of modulo 2. (F) *Hirsch*

**142. Elementary Algebraic Topology. (3).** *Formerly 142.* Three 1-hour lectures per week. *Prerequisites: 104 and 113A.* The topology of one and two dimensional spaces: manifolds and triangulation, classification of surfaces, Euler characteristic, fundamental groups, plus further topics at the discretion of the instructor. (SP) *Dubins*

**145. Boolean Algebra. (3).** *Formerly 145.* Three 1-hour lectures per week. *Prerequisites: 125A.* Postulates; treatment as rings or lattices: relation to sentential calculus and calculus of classes; infinite operations; atoms; subalgebras, ideals, direct products; representation theorem. Not offered 1985–86.

**160. History of Mathematics. (3).** *Formerly 160.* Three 1-hour lectures per week. *Prerequisites: 50B and 113A.* History of algebra, geometry, analytic geometry, and calculus from ancient times through the seventeenth century and selected topics from more recent mathematical history. Not offered 1985–86.

**163. Tutorial in Upper Division Mathematics. (3).** *Formerly 163.* May be repeated for credit with consent of instructor. Flexible. *Prerequisites: 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, and classical linear groups. Content varies. Not offered 1985–86.

**170. Linear Programming, Games, Models of Exchange. (3).** *New Course.* Three 1-hour lectures per week. *Prerequisites: 50A-50B.* Topics include linear programming, matrix games, models of production and exchange. Treats properties of the models and methods for calculating their behavior. (F) *Gale*

**185. Introduction to the Theory of Functions of a Complex Variable. (4).** *Formerly 185.* Three 1-hour lectures per week. *Prerequisites: 104.* Analytic functions of a complex variable. Cauchy's integral theorem, power series, Laurent series, singularities of analytic functions, the residue theorem with application to definite integrals. Some additional topics such as conformal mapping. (F,SP) *Silver, Harrington, Protter*

**H185. Introduction to the Theory of Functions of a Complex Variable. (4).** *Formerly H185.* Three 1-hour lectures per week. *Prerequisites: 104.* Honors section corresponding to Math 185 for exceptional students with strong mathematical inclination and motivation. Emphasis is on rigor, depth, and hard problems. (SP) *Hald*

**187. Senior Level Analysis. (3).** *New Course.* Three 1-hour lectures per week. *Prerequisites: 104, 113, and 185.* Course gives a comprehensive view of analysis. Emphasis is on the interrelations among topics taken from differential equations, harmonic analysis and group representation, elementary functional analysis and special functions. (SP) *Chernoff*

**188. Mathematical Models in Physics and Engineering. (3).** *Formerly 188.* Three 1-hour lectures per week. *Prerequisites: 112 or 113B; 185 or 120B or 121B.* Designed primarily for mathematics majors with little or no background in physical sciences. Study of the relationship between mathematical concepts such as discrete and continuous spectra, resolvents of linear operators, group invariance, and physical concepts which arise in the study of dynamical systems and wave propagation. Not offered 1985–86.

**191. Experimental Courses in Mathematics. (1-4).** *Formerly 191.* May be repeated for credit. Flexible. *Prerequisites: Consent of instructor.* The topics to be covered and the method of instruction to be used will be announced at the beginning of each semester that such courses are offered. See departmental bulletins. Not offered 1985-86. Varies, as announced

**195. Special Topics in Mathematics. (3).** *Formerly 195.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Lectures on special topics, which will be announced at the beginning of each semester that the course is offered. (F) *Berlekamp*

**196. Honor Thesis. (3).** *Formerly 196.* May be repeated for credit. Unscheduled. *Prerequisites: Admission to the Honors Program; an overall GPA of 3.0 and a GPA of 3.30 in the major.* Independent study of an advanced topic leading to an honors thesis. (F,SP) Varies, as announced.

**199. Supervised Independent Study and Research. (1-4).** *Formerly 199.* Must be taken on a *passed/not passed* basis. Flexible. *Prerequisites: The standard college regulations for all 199 courses.* (F,SP)

### *Graduate Courses*

**202A. Introduction to Topology and Analysis. (4).** *Formerly 202A-202B.* Three 1-hour lectures per week. *Prerequisites: 104.* General topological spaces. Metric spaces. Compactness and connectedness. Theorems of Tychonoff, Urysohn, Tietze. Baire category theorem. Function spaces. Arzela-Ascoli and Stone-Weierstrass theorems. Introduction to linear topological spaces. Banach and Hilbert spaces. Banach-Steinhaus, closed graph theorems. Convexity. Hahn-Banach theorem. Weak and weak-* topologies. Banach-Alaoglu theorem. Krein-Milman theorem. Additional topics selected by the instructor. (F,SP) *Bade, Moore, Helson*

**202B. Introduction to Topology and Analysis. (4).** *Formerly 202B-202C.* Three 1-hour lectures per week. *Prerequisites: 202A.* Measure theory and Lebesgue integration. Convergence theorems. Lp spaces. Product

Berkeley '85 - '86



spaces, Fubini type theorems. Signed measures. Hahn and Jordan decomposition. Radon-Nikodym theorem. Integration on the line and in $R^n$. Differentiation of the integral. Fourier transform. Duality, the dual of Lp. Measures in locally compact spaces, the dual of C(X). Additional topics chosen may include compact operators, spectral theory of compact operators. Application to integral equations. (SP) *Bade*

**204A-204B. Ordinary and Partial Differential Equations. (4;4).** *Formerly 204A-204B-204C.* Three 1-hour lectures per week. *Prerequisites: 105 and 185 or consent of instructor.* Fundamental existence theorem for ordinary differential equations. Properties of linear systems with constant and periodic coefficients. Sturm-Liouville theory; Poincare-Bendixson Theorem. Cauchy-Kowalewski theory for systems of partial differential equations. Initial and boundary value problems for elliptic, parabolic, and hyperbolic second order equations. Nonlinear equations and systems. (F,SP) *Kato*

**205. Theory of Functions of a Complex Variable. (3).** *Formerly 205.* Three 1-hour lectures per week. *Prerequisites: 185.* Normal families. Riemann Mapping Theorem. Picard's theorem and related theorems. Multiple-valued analytic functions and Riemann surfaces. Further topics selected by the instructor may include: harmonic functions, elliptic and algebraic functions, boundary behavior of analytic functions and HP spaces, the Riemann zeta functions, prime number theorem. (F) *Jones*

**206. Banach Algebras and Spectral Theory. (3).** *Formerly 206A-206B.* Three 1-hour lectures per week. *Prerequisites: 202A-202B.* Banach algebras. Spectrum of a Banach algebra element. Gelfand theory of commutative Banach algebras. Analytic functional calculus. Hilbert space operators. C*-algebras of operators. Commutative C*-algebras. Spectral theorem for bounded self-adjoint and normal operators (both forms: the spectral integral and the "multiplication operator" formulation). Riesz theory of compact operators. Hilbert-Schmidt operators. Fredholm operators. The Fredholm index. Selected additional topics. (F) *Sarason*

**207. Unbounded Operators. (3).** *Formerly 207.* Three 1-hour lectures per week. *Prerequisites: 206.* Unbounded self-adjoint operators. Stone's Theorem, Friedrichs extensions. Examples and applications, including differential operators. Perturbation theory. Further topics may include: unbounded operators in quantum mechanics, Stone-Von Neumann Theorem. Operator semigroups and evolution equations, some non-linear operators. Weyl theory of defect indices for ordinary differential operators. (SP) *Majda*

**209. Operator Algebras. (4).** *Formerly 209A.* Three 1-hour lectures per week. *Prerequisites: 206.* Elementary C*-algebra theory. Connections with group representations. Basic von Neumann algebra theory. Density theorems, normal states, traces. Further topics may include: basic K-theory of C*-algebras, applications to physics such as the Stone-von Neumann theorem, automorphism groups, C*-dynamical systems. (F) *Rieffel*

**210. Nonlinear Functional Analysis. (3).** *Formerly 208.* Three 1-hour lectures per week. *Prerequisites: 202A-202B.* Fixed-point theorems. Monotone and accretive operators. Non-linear semigroups and evolution equations. Application to PDE. Topics are selected by the instructor. Not offered 1985–86.

**211. Mathematical Theory of Fluid Mechanics. (3).** *Formerly 211.* Three 1-hour lectures per week. Development of the fundamental equations describing the behavior of fluid continuum followed by the treatment of special topics selected to exhibit different physical situations, analytical techniques, and approximate methods of solutions. (SP) *Neu*

**212. Several Complex Variables. (3).** *Formerly 212A-212B.* Three 1-hour lectures per week. *Prerequisites: 185 and 202A-202B or their equivalents.* Power series developments, domains of holomorphy, Hartogs' phenomenon, pseudo convexity and plurisubharmonicity. The remainder of the course may treat either sheaf cohomology and Stein manifolds, or the theory of analytic subvarieties and spaces. (SP) *Sarason*

**IDS 213A-213B. Mathematical Economics. See IDS courses at end of Mathematics course listings.**

**214. Differentiable Manifolds.. (3).** *Formerly 214.* Three 1-hour lectures per week. *Prerequisites: 202A-202B.* Smooth manifolds and maps, tangent and normal bundles. Sard's theorem and transversality, Whitney embedding theorem. Morse functions, differential forms, Stokes' theorem, Frobenius theorem. Basic degree theory. Flows, Lie derivative, Lie groups and algebras. Additional topics selected by instructor. (F,SP) *Hsiang, Hirsch*

**215A-215B. Algebraic Topology. (3;3).** *Formerly 215A-215B-215C.* Three 1-hour lectures per week. *Prerequisites: 113B, 202A, and 214.* Fundamental group and covering spaces, simplicial and singular homology theory with applications, cohomology theory, duality theorem. Homotopy theory, fibrations, relations between homotopy and homology, obstruction theory, and topics from spectral sequences, cohomology operations, and characteristic classes. (F,SP) *Thomas*

**219. Ordinary Differential Equations and Modern Flow Theory and Structural St. (3).** *Formerly 219A-219B.* Three 1-hour lectures per week. *Prerequisites: 214.* Ordinary differential equations. Diffeomorphisms and flows on manifolds. Stable manifolds, generic properties, structural stability. Special topics selected by the instructor. (F) *Pugh*

**220A. Applied Mathematics for Physical Sciences and Engineering. (3).** *Formerly 220A-220B.* Three 1-hour lectures per week. *Prerequisites: 120B, 121B, or both 104 and 185.* Ordinary and partial differential equations of mathematical physics and engineering. Special functions. (F) *Chambré*

**220B. Applied Mathematics for Physical Sciences and Engineering. (3).** *Formerly 220B-220C.* Three 1-hour lectures per week. *Prerequisites: 220A.* Integral transforms, integral equations. Variational methods for partial differential equations. (SP) *Chambré*

**221. Advanced Matrix Computations. (3).** *Formerly 221.* Three 1-hour lectures per week. *Prerequisites: 128A-128B, or equivalent experience with matrix computation.* Direct solution of linear systems, including large sparse systems: error bounds, iteration methods, least square approximation, eigenvalues and eigenvectors of matrices, nonlinear equations, and minimization of functions. (F) *Hald*

**222A-222B. Partial Differential Equations. (3;3).** *Formerly 222A-222B-222C.* Three 1-hour lectures per week. *Prerequisites: 105 or 202B; 185.* The theory of initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations, with emphasis on nonlinear equations. More general types of equations and systems of equations. (F,SP) *Cordes*

**224A-224B. Mathematical Methods for the Physical Sciences. (3;3).** *Formerly 224A-224B-224C.* Three 1-hour lectures per week. *Prerequisites: 112 or 113B; 104 and 185, or 121A-121B, or 120A-120B.* Introduction to the theory of distributions. Fourier and Laplace transforms. Partial differential equations. Green's function. Operator theory, with applications to one-parameter unitary groups, eigenfunction expansions, perturbation theory. (F,SP) *Grunbaum*

**225A-225B. Metamathematics. (3;3).** *Formerly 225A-225B-225C.* Three 1-hour lectures per week. *Prerequisites: 125B and 135.* Metamathematics of predicate logic. Completeness and compactness theorems. Interpolation theorem, definability, theory of models. Metamathematics of number theory, recursive functions, applications to truth and provability. Undecidable theories. (F,SP) *Harrington*

**226A. Abstract Machines and Languages. (3).** *Formerly 226A-226B.* Three 1-hour lectures per week. *Prerequisites: 113B and 135 or consent of instructor.* Finite state automata, regular sets, Turing machines, recursive functions, decision problems. Context-free languages, pushdown automata, ambiguity, special families of languages, power series in non-commuting variables. Not offered 1985–86.

**226B. Semigroups and Machines. (3).** *Formerly 226B-226C.* Three 1-hour lectures per week. *Prerequisites: 226A or consent of instructor.* Semigroups, wreath products, prime decomposition theorem, application to finite state machines, algebraic theory of complexity. Not offered 1985–86.

**227A-227B. Theory of Recursive Functions. (3;3).** *Formerly 227A-227B.* Three 1-hour lectures per week. *Prerequisites: 225B.* Recursive and recursively enumerable sets of natural numbers; characterizations, significance, and classification. Relativization, degrees of unsolvability. The recursion theorem. Constructive ordinals, the hyperarithmetical and analytical hierarchies. Recursive objects of higher type. Not offered 1985–86.

**228A-228B. Numerical Solution of Differential Equations. (4;4).** *Formerly 228A-228B.* Three 1-hour lectures per week. *Prerequisites: 128A-128B.* Ordinary differential equations, elementary methods, including Runge-Kutta and predictor-corrector methods: stability theory, Richardson extrapolation, stiff equations, boundary value problems, variational methods, singular perturbations. Partial differential equations: stability, accuracy, and convergence, Von Neumann's condition, finite difference solution of hyperbolic and parabolic equations, the Courant-Friedrichs-Lewy condition, numerical dissipation and dispersion, finite differences and finite element solution of elliptic equations. The solution of ordinary differential equations will be discussed in 228A. (F,SP) *Miller*

**229. Theory of Models. (3).** *Formerly 229A-229B.* Three 1-hour lectures per week. *Prerequisites: 225B.* Syntactical characterization of classes closed under algebraic operations. Ultraproducts and ultralimits, saturated models. Methods for establishing decidability and completeness. Model theory of various languages richer than first-order. (F) *Vaught*

**235A-235B. Theory of Sets. (3;3).** *Formerly 235A-235B-235C.* Three 1-hour lectures per week. *Prerequisites: 125A and 135.* Axiomatic foundations: Operations on sets and relations. Images and set functions. Ordering, well-ordering, and well-founded relations; general principles of induction and recursion. Ranks of sets, ordinals and their arithmetic. Set-theoretical equivalence, similarity of relations; definitions by abstraction. Arithmetic of cardinals. Axiom of choice, equivalent forms, and consequences. (F,SP) *Solovay*

**236. Metamathematics of Set Theory. (3).** *Formerly 236A-236B.* Three 1-hour lectures per week. *Prerequisites: 225B and 235A.* Various set theories: comparison of strength transitive and natural models, finite axiomatizability. Independence and consistency of axiom of choice, continuum hypothesis, etc. The measure problem and axioms of strong infinity. (SP) *Silver*

**240. Riemannian Geometry. (3).** *Formerly 240A-240B.* Three 1-hour lectures per week. *Prerequisites: 214.* Riemannian metric and Levi-Civita connection, geodesics and completeness, curvature, first and second variations of arc length. Additional topics such as the theorems of Myers, Synge, and Cartan-Hadamard, the second fundamental form, convexity and rigidity of hypersurfaces in Euclidean space, homogeneous manifolds, the Gauss-Bonnet theorem, and characteristic classes. (F) *Schoen*

**241. Complex Manifolds. (3).** *Formerly 241A-241B.* Three 1-hour lectures per week. *Prerequisites: 214 and 215A.* Riemann surfaces, divisors and line bundles on Riemann surfaces, sheaves and the Dolbeault theorem on Riemann surfaces, the classical Riemann-Roch theorem, theorem of Abel-Jacobi. Complex manifolds, Kahler metrics. Summary of Hodge theory, groups of line bundles, additional topics such as Kodaira's vanishing theorem, Lefschetz hyperplane theorem. (F) *Wolf*

**245A-245B. General Theory of Algebraic Structures. (3;3).** *Formerly 245A-245B-245C.* Three 1-hour lectures per week. *Prerequisites: 113A and 135.* Structures defined by operations and/or relations, and their homomorphisms. Classes of structures determined by identities. Constructions such as free objects, objects presented by generators and relations, ultraproducts, direct limits. Applications of general results to groups, rings, lattices, etc. Course may emphasize study of congruence- and subalgebra-lattices, or category-theory and adjoint functors, or other aspects. (F) *Bergman*

**Notes: For key to symbols, see page 48.**

Berkeley '85-86

**250A. Groups, Rings, and Fields. (4).** *Formerly 250A-250B.* Three 1-hour lectures per week. *Prerequisites: 113A-113B or their equivalents.* Group theory, including the Jordan-Holder theorem and the Sylow theorems. Basic theory of rings and their ideals. Unique factorization domains and principal ideal domains. Modules. Chain conditions. Fields, including fundamental theorem of Galois theory, theory of finite fields, and transcendence degree. (F) *Seidenberg, Bergman*

**250B. Multilinear Algebra and Further Topics. (4).** *Formerly 250B-250C.* Three 1-hour lectures per week. *Prerequisites: 250A.* Tensor algebras and exterior algebras, with application to linear transformations. Commutative ideal theory, localization. Elementary specialization and valuation theory. Related topics in algebra. (SP) *Bergman*

**251. Ring Theory. (3).** *Formerly 251.* Three 1-hour lectures per week. *Prerequisites: 250A.* Topics such as: Noetherian rings, rings with descending chain condition, theory of the radical, homological methods. Not offered 1985–86.

**252. Representation Theory. (3).** *Formerly 252.* Three 1-hour lectures per week. *Prerequisites: 250A.* Structure of finite dimensional algebras, applications to representations of finite groups, the classical linear groups. (SP) *Goldschmidt*

**253. Homological Algebra. (3).** *Formerly 253.* Three 1-hour lectures per week. *Prerequisites: 250A.* Modules over a ring, homomorphisms and tensor products of modules, functors and derived functors, homological dimension of rings and modules. Not offered 1985–86.

**254A-254B. Number Theory. (3;3).** *Formerly 254A-254B.* Must be taken on a *satisfactory/unsatisfactory* basis. Three 1-hour lectures per week. *Prerequisites: 250A.* Valuations, units, and ideals in number fields, ramification theory, quadratic and cyclotomic fields, topics from class field theory, zeta-functions and L-series, distribution of primes, modular forms, quadratic forms, diophantine equations, P-adic analysis, and transcendental numbers. (F,SP) *Coleman*

**255A-255B. Foundations of Geometry. (3;3).** *Formerly 255A-255B-255C.* Three 1-hour lectures per week. *Prerequisites: 125B and 130.* Historical introduction. Primitive terms and axioms of Euclidean geometry. Principal consequences of axioms; introduction to Cartesian coordinates. Completeness, categoricity, decidability; independence of axioms. Alternative systems of primitive terms and axioms. Non-Euclidean geometries—parallel development to Euclidean geometry. Not offered 1985–86.

**256A-256B. Algebraic Geometry. (3;3).** *Formerly 256A-256B-256C.* Three 1-hour lectures per week. *Prerequisites: 250A.* Affine and projective algebraic varieties. Theory of schemes and morphisms of schemes. Smoothness and differentials in algebraic geometry. Coherent sheaves and their cohomology. Riemann-Roch theorem and selected applications. (F,SP) *Hartshorne*

**257. Group Theory. (3).** *Formerly 257.* Three 1-hour lectures per week. *Prerequisites: 250A.* Topics such as: generators and relations, infinite discrete groups, groups of Lie type, permutation groups, character theory, solvable groups, simple groups, transfer and cohomological methods. (F) *McKenzie*

**258. Classical Harmonic Analysis. (3).** *Formerly 258.* Three 1-hour lectures per week. *Prerequisites: 206 or a basic knowledge of real, complex, and linear analysis.* Basic properties of Fourier series, convergence and summability, conjugate functions, Hardy spaces, boundary behavior of analytic and harmonic functions. Additional topics at the discretion of the instructor. Not offered 1985–86.

**259. Transformation Groups. (3).** *Formerly 259.* Three 1-hour lectures per week. *Prerequisites: 215A and 214.* Topological groups, Haar measure, general theory of topological transformation groups, the existence of slices and applications, the Smith theory of periodic transformations. (SP) *Lashof*

**260. Abstract Harmonic Analysis. (3).** *Formerly 260B.* Three 1-hour lectures per week. *Prerequisites: 206.* Topological groups, Haar measure, Pontryagin duality, and structure theory of locally compact abelian groups, Peter-Weyl theorem for compact groups. Further topics may include finer study of harmonic analysis on commutative groups, or else head in the direction of group representations for noncommutative locally compact groups. (F) *Staff*

**261A-261B. Lie Groups. (3;3).** *Formerly 261A-261B-261C.* Three 1-hour lectures per week. *Prerequisites: 214.* Lie groups and Lie algebras, fundamental theorems of Lie, general structure theory; compact, nilpotent, solvable, semi-simple Lie groups; classification theory and representation theory of semi-simple Lie algebras and Lie groups, further topics such as symmetric spaces, Lie transformation groups, etc., if time permits. In view of its simplicity and its wide range of applications, it is preferable to cover compact Lie groups and their representations in 261A. (F,SP) *Hsiang*

**265. Differential Topology. (3).** *Formerly 265.* Three 1-hour lectures per week. *Prerequisites: 214 plus 215A or some familiarity with algebraic topology.* Approximations, degrees of maps, vector bundles, tubular neighborhoods. Introduction to Morse theory, handlebodies, cobordism, surgery. Additional topics selected by instructor from: characteristic classes, classification of manifolds, immersions, embeddings, singularities of maps. (F) *Kirby*

**271. Topics in Foundations. (3).** *Formerly 271.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (SP) *Staff*

**273. Advanced Numerical Analysis. (3).** *Formerly 273.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Topics of current interest in numerical analysis and its applications. Not offered 1985-86.

273A. Ordinary Differential Equations. (3).

273B. Initial Value Problems. (3).

273C. Boundary Value Problems. (3).

273D. Finite Element Methods. (3).

273E. Topics in Numerical Linear Algebra. (3).

273F. Topics in Computational Physics. (3).

273G. Nonlinear Equations and the Minimization of Functions. (3).

273H. Monte Carlo Methods. (3).

273I. Approximation Theory. (3).

273J. Ill-Posed Problems. (3).

273K. Inverse Problems. (3).

**274. Topics in Algebra. (3).** *Formerly 274.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (F,SP) *Ogus, Lam*

**275. Topics in Applied Mathematics. (3).** *Formerly 275.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (F,SP) *Grunbaum, Smale, Marsden*

**276. Topics in Topology. (3).** *Formerly 276.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (F,SP) *Taubes, Kirby*

**277. Topics in Differential Geometry. (3).** *Formerly 277.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (SP) *Kobayashi*

**278. Topics in Analysis. (3).** *Formerly 278.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (SP) *Rieffel, Pugh, Jones*

**279. Topics in Partial Differential Equations. (3).** *Formerly 279.* May be repeated for credit. Three 1-hour lectures per week. *Prerequisites: Consent of instructor.* Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars. (F) *di Perna*

**280A-280B. Mathematical Theory of Relativity. (3;3).** *Formerly 280A-280B-280C.* Three 1-hour lectures per week. *Prerequisites: 140 or consent of instructor.* Special theory of relativity, reformulation of classical physical theories in relativistic form, principle of equivalence, Einstein's theory of gravitation, astrophysical and cosmological problems. Additional topics chosen by the instructor. (F,SP) *Schoen*

**290. Seminars. (1-6).** *Formerly 290.* May be repeated for credit. Varies. Topics in foundations of mathematics, theory of numbers, numerical calculations, analysis, geometry, topology, algebra, and their applications, by means of lectures and informal conferences; work based largely on original memoirs. (F,SP) *Staff*

**295. Individual Research. (1-9).** *Formerly 295.* May be repeated for credit. Sections 1-20: letter grading; sections 21-60: *S/U* grading. By appointment. Intended for candidates for the Ph.D. degree. (F,SP) *Staff*

**299. Reading Course for Graduate Students. (1-6).** *Formerly 299.* May be repeated for credit. Sections 1-20: letter grading; sections 21-60: *S/U* grading. By appointment. Investigation of special problems under the direction of members of the department. (F,SP) *Staff*

**600. Individual Study for Master's Students. (1-6).** *Formerly 600.* Units may not be used to meet either unit or residence requirements for a master's degree. May be repeated for credit. Must be taken on a *satisfactory/unsatisfactory* basis. By appointment. *Prerequisites: For candidates for master's degree.* Individual study for the comprehensive or language requirements in consulation with the field adviser. (F,SP) *Staff*

*Professional Courses*

**300. Teaching Workshop. (3).** *Formerly 300.* Must be taken on a *satisfactory/unsatisfactory* basis. Two 1-hour lectures per week, plus class visits. Designed for teaching assistants with little or no teaching experience. The course consists of practice teaching, alternatives to standard classroom methods, guided group and self-analysis of videotapes, reciprocal classroom visitations, and an individual project. (F,SP) *Staff*

**301. Undergraduate Math Instruction. (1-2).** May be taken for one unit by special permission of instructor. Course may be repeated once for credit. Must be taken on a *passed/not passed* basis. *Prerequisites: Permission of Student Learning Center, as well as sophomore standing and at least a B average in two semesters of calculus. Apply at SLC, Building T-8 during pre-enrollment.* Two to three hours of seminar and four hours (for 2 units) of tutoring per week at the Student Learning Center or the Professional Development Program. (F,SP) *Staff*

**Interdepartmental Studies Courses**

*Upper Division Courses*

**IDS103. Introduction to Mathematical Economics. (3).** Students who have taken Economics 104 will receive no credit for IDS 103. Three hours of lecture per week. *Prerequisites: Math 50A-50B.* Selected topics illustrating the application of mathematics to economic theory. This course is intended for upper division students in mathematics, statistics, the physical sciences, and engineering, and for economics majors with adequate mathematical preparation. No economic background is required. Sponsoring Departments: Mathematics and Economics. (SP)

*Graduate Courses*

**IDS213A-213B. Mathematical Economics. (3;3).** Two hours of lecture per week. *Prerequisites: Math 104 and 112 and Statistics 101.* Mathematical analysis of economic theory. The problems treated involve as wide a range of mathematical techniques and of economic

Berkeley '85-'86



topics as possible, including theories of preferences, utility, demand, personal probability, games and general equilibrium. This course requires at least twelve hours of work per week including outside work and preparation. Sponsoring Departments: Economics and Mathematics. (F,SP)

# Medieval Studies

*Chair and Graduate Adviser:* To be announced.

Medieval studies are currently undertaken in a joint degree program designed to preserve the established standards of training in a major subject while broadening the student's experience in other aspects of the field. The degree granted in recognition of this extra achievement is the Ph.D. with a joint designation, for example, "Ph.D. in English and Medieval Studies." Each student is expected to fulfill the Ph.D. requirements of the major department of study, which administers the program of study. In addition, each student pursues seminar work in two outside departments, one of which is History (unless that is the department of the major). The program includes a special examination in Latin, consisting of representative passages from medieval authors. Interested students should apply for admission to the individual department in which they would do their major work.

There is no undergraduate major. Students whose interests lie in the medieval period should consider the possibility of setting up an individual major (for requirements see the *Announcement of the College of Letters and Science*).

The student is also urged to consult the medieval offerings in the departments of: Art and History of Art, Classics, Comparative Literature, Dramatic Art, English, French, German, History, Italian, School of Law, School of Library and Information Studies, Linguistics, Music, Near Eastern Studies, Philosophy, Rhetoric, Romance Philology, Scandinavian, Slavic, South and Southeast Asian Studies, Spanish and Portuguese, and the Graduate Theological Union. An updated list of such offerings is issued each fall by the Chair of the Committee.

*Upper Division Courses*

**150. Studies in Medieval Culture. (3).** *Formerly 150A-150B.* Course may be repeated for credit. Three one-hour lectures per week. Taught by the Distinguished Visiting Professor for the current year on a topic related to his or her specialty. (F) *Derolez*

*Graduate Courses*

**200. Introduction to Research Materials and Methods. (2).** Must be taken on a *satisfactory/unsatisfactory* basis. One 2-hour meeting per week: lecture & discussion. *Prerequisites: Graduate standing.* Basic materials and resources in fields represented in the Medieval Studies program, and in some subjects involving expertise in more than one discipline (e.g. liturgy, codicology). Emphasis on research aids and critical evaluation of their use. (SP) *Staff*

**250. Seminar in Medieval Culture. (3).** *Formerly 250A-250B.* Course may be repeated for credit. One three-hour lecture per week. *Prerequisites: Graduate standing.* Taught by the Distinguished Visiting Professor for the current year on a topic related to his or her specialty. (F) *Derolez*

# Microbiology and Immunology

**Department Office, 3573 Life Sciences Building, 642-3771**

**Professors:**

James Allison, Ph.D.
Phyllis B. Blair,[3] Ph.D.
Alexander Glazer, Ph.D.
Marian E. Koshland, Ph.D. *(Chair)*
Terrance Leighton, Ph.D.
Robert I. Mishell, M.D.
Hiroshi Nikaido, M.D., D. Med. Sc.
Jeremy Thorner, Ph.D.
David Zusman,[1] Ph.D.
Leon Wofsy, Ph.D. *(Emeritus)*

**Assistant Professors:**

Dennis Ohman, Ph.D.
Hitoshi Sakano, Ph.D.

**Senior Lecturer:**

Anne H. Good, M.D., Ph.D. *(Vice Chair)*

**Adjunct Professor:**

Robert Goodenow, Ph.D.
G. Steven Martin, Ph.D.
H. Claudia Henry, Ph.D.

*Major Advisers:* Mrs. Blair, Mr. Glazer, Mr. Mishell, Mr. Ohman, Mr. Sakano, Mr. Zusman.

*Graduate Advisers:* Mrs. Good, Mr. Leighton.

Students who are interested in the major in microbiology are urged to consult the major adviser concerning the specific courses to be taken as a basis for the major.

The Department of Microbiology and Immunology offers an undergraduate major in microbiology, and graduate training in both microbiology and immunology. The undergraduate major, administered according to two plans, provides training in microbiology at the upper division level on the basis of preparation at the lower division level in general biology and physical science. Plan I is strongly recommended for all students who plan to undertake subsequent graduate work. Honor students with a special interest in immunology may arrange an individual major program in this area with the approval of the undergraduate adviser.

## The Major

Minimum Scholarship: Required for graduation in the major are grades of C- or better in 100 and 100L, 101 and 101L, Biochemistry 102 and 102L, BEHS 105 and 105L, or their equivalents.

### Plan I

**Lower Division.** Chemistry 1A-1B, 5, 8A-8B or 112A-112B; Mathematics 16A-16B or 1A-1B; Physics 8A; Biology 1A. Biology 1B and Physics 8B are strongly recommended for students planning further graduate or professional study.

**Upper Division.** Microbiology 100-100L, 101, 101L; Biochemistry 102 or 100A-100B, 102L or 101; Chemistry 130A or Genetics 102 or the equivalent; plus a minimum of 6 units of additional upper division coursework in other pertinent subjects in the biological sciences such as virology, mycology, algology, protozoology, cell and developmental biology. Students focusing on immunology are required to take Microbiology 103 and 103L.

### Plan II

**Lower Division.** Chemistry 1A-1B, 5, 8A-8B; Mathematics 16A or 1A and either Mathematics 16B, 1B, Statistics 2 or Computer Science 7; Physics 8A; Biology 1A. Biology 1B and Physics 8B are strongly recommended for students planning further graduate or professional study.

**Upper Division.** Microbiology 100-100L; Biochemistry 102, 102L; Biomedical and Environmental Health Sciences 105, 105L; plus a minimum of 6 units of additional upper division coursework in other pertinent subjects in the biological sciences, such as immunology, hematology, parasitology, histology, endocrinology, and applied aspects of microbiology.

**Honors Program.** With the consent of the major adviser, students with an overall grade-point average of 3.3 or higher and a grade-point average of 3.3 or higher in courses in the major may apply for admission to the honors program. Students enrolled in the program must take at least 4 units of research courses (H195 and/or H196) and must present the results of their research in a paper and in a seminar at the end of their last semester. The honors program adviser will help plan each honors program individually; approval of the program by the honors program adviser is required. The honors program adviser is authorized to exempt students in the honors program from requirements concerning specific courses or sequences of courses in the major. Students interested in enrolling in the program should consult the honors program adviser (Mrs. Blair).

**Preparation for Graduate Study.** For the pursuit of graduate work in either microbiology or immunology, the undergraduate training outlined under Plan I is preferable. Other courses strongly recommended as basic preparation for future graduate work are: Chemistry 130A; Chemistry 112E (for students who have taken Chemistry 112A). Useful foreign languages include French, German, Russian, and Japanese; German is recommended.

## The Graduate Program

The Department offers the M.A. and Ph.D. degrees in microbiology and immunology. There is no separate M.A. program; the M.A. degree is usually earned as part of the doctoral program. The completion of teaching assignments for a minimum of two semesters is required of all students working for the Ph.D. degree in microbiology or in immunology. Information is available from the graduate adviser in 3573 Life Sciences Building.

*Lower Division Courses*

**2. Enology—The Microbiology and Biochemistry of Winemaking. (1.5).** One 1½-hour lecture/discussion per week. *Prerequisites: High school biology and high school chemistry.* The microbial history, ecology, biochemical physiology and genetics of organisms affecting the production and stability of various wine types produced throughout the world. Microbiological and biochemical factors affecting wine quality will also be discussed. One take-home midterm (essay) and one take-home final (essay) will be employed to determine student performance. (F) *Leighton*

**6. Immunity and Defense. (2).** *Formerly 6.* No credit for students who have completed 8 or 10. Must be taken on a *passed/not passed* basis. One 2-hour session per week. *Prerequisites: High school biology; Freshman status.* Lectures and discussion centering on the organism's biological defenses against its environment. Topics will be limited in number, but explored in depth suitable for freshmen who plan to major in a biological science. (SP) *Blair*

**8. Cancer and Immunology. (1).** *New Course.* Students who have taken 6 or 10 will receive no credit for 8. Must be taken on a *passed/not passed* basis. One 1-hour session per week. *Prerequisites: High school biology; freshman status.* Lectures and discussion centering on the factors involved in the development of cancer and the role that the immune system can play in its detection and its prevention. Topics will be limited in number but explored in depth suitable for freshman who plan to major in a biological science. (F) Odd years only. *Blair*

**10. The Microscopic World. (3).** Students who have received credit for 6 or 8 will receive only two units for 10. Must be taken on a *passed/not passed* basis. Two 1½-hour lectures per week. *Prerequisites: High school chemistry or Chemistry 1A; high school biology or Biology 1A.* An introduction to the biology of microorganisms and the immune system; the fundamental principles of and major advances in microbiology and immunology. Intended for students interested in microbiology; suitable for those not majoring in a biological science. (SP) *Blair, Leighton*

*Upper Division Courses*

**100. Introduction to Microbiology. (3).** *Formerly 102 or 100A.* Three 1-hour lectures per week. *Prerequisites: Biology 1A, Chemistry 5, Chemistry 8A-8B.* A survey of general microbiology which introduces the methodology of microbiology and stresses the basic biological properties of microorganisms, and prokaryotic cells in particular, including their growth, physiological diversity, structure, and ecobiology. (F) *Glazer, Nikaido*

**100L. Microbiology Laboratory. (3).** *Formerly 102L or 101A.* One 1-hour lecture and two 4-hour laboratories per week. *Prerequisites: 100 (may be taken concurrently).* Experimental work, designed to accompany course 100, which acquaints the student with the isolation of bacteria from natural habitats, methods of culture and microscopic observation, and the structural and physiological features of microbial cells. (F) *Ohman*

Note: For key to symbols, see page 48.