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298. Special Study. (1–5) I and II. Staff

299. Directed Research. (1–5) I and II. Staff

RELATED COURSES

Language and Culture (Anthrop...
Language (English 25, Mr. Reed)
Modern English (English 211J, M...
Germanic Linguistics (German 26...
Comparative Grammar of Greek a... lm-bold).
Linguistic History of the Roman... Mr. Malkiel).
Late Latin Language and Literatur... Mr. Malkiel).
General Romance Linguistics (Roma... 202, Mr. Malkiel).
Comparative Romance Phonetics (Romance Philology 204, Mr. Carmody).
Linguistic Geography Applied to Romance Dialectology (Romance Philology 205, Mr. Malkiel).
Comparative Slavic Linguistics (Slavic Languages 220, Mr. Whitfield).
General Phonetics (Speech 103, Mr. Chrétien).

1954 – 1955

MATHEMATICS

(Department Office, 5319 Dwinelle Hall)

[2]Alfred L. Foster, Ph.D., *Professor of Mathematics.*
John L. Kelley, Ph.D., *Professor of Mathematics (Vice-Chairman of Department).*
Erich L. Lehmann, Ph.D., *Professor of Mathematics.*
Derrick H. Lehmer, Ph.D., *Professor of Mathematics (Chairman of the Department).*
Hans Lewy, Ph.D., *Professor of Mathematics.*
*Michel Loève, Docteur ès Sciences, *Professor of Mathematics.*
Sophia Levy McDonald, Ph.D., *Professor of Mathematics.*
*Charles B. Morrey, Jr., Ph.D., *Professor of Mathematics.*
Anthony P. Morse, Ph.D., *Professor of Mathematics.*
Jerzy Neyman, Ph.D., *Professor of Mathematics and Director of the Statistical Laboratory.*
Raphael M. Robinson, Ph.D., *Professor of Mathematics.*
Henry Scheffé, Ph.D., *Professor of Statistics and Assistant Director of the Statistical Laboratory.*
Alfred Tarski, Ph.D., *Professor of Mathematics.*
Frantisek Wolf, Ph.D., *Professor of Mathematics.*
Benjamin A. Bernstein, Ph.D., *Professor of Mathematics, Emeritus.*
Thomas Buck, Ph.D., *Professor of Mathematics, Emeritus.*
Griffith C. Evans, Ph.D., *Professor of Mathematics, Emeritus.*
Charles A. Noble, Ph.D., *Professor of Mathematics, Emeritus.*
Raymond H. Sciobereti, Ph.D., *Associate Professor of Mathematics, Emeritus.*
Pauline Sperry, Ph.D., *Associate Professor of Mathematics, Emeritus.*
Lee H. Swinford, Ph.D., *Assistant Professor of Mathematics, Emeritus.*
Arthur R. Williams, Ph.D., *Assistant Professor of Mathematics, Emeritus.*

* Absent on leave, 1954–1955.
[2] In residence spring semester only, 1954–1955.

*Edward W. Barankin, Ph.D., *Associate Professor of Mathematics.*
*Leon A. Henkin, Ph.D., *Associate Professor of Mathematics.*
Joseph L. Hodges, Jr., Ph.D., *Associate Professor of Mathematics.*
Edmund Pinney, Ph.D., *Associate Professor of Mathematics.*
Murray Harold Protter, Ph.D., *Associate Professor of Mathematics.*
Abraham Seidenberg, Ph.D., *Associate Professor of Mathematics.*
Paul L. Chambré, Ph.D., *Assistant Professor of Mathematics.*
Stephen P. Diliberto, Ph.D., *Assistant Professor of Mathematics.*
Evelyn A. Fix, Ph.D., *Assistant Professor of Mathematics.*
Harley Flanders, Ph.D., *Assistant Professor of Mathematics.*
Terry A. Jeeves, Ph.D., *Assistant Professor of Mathematics.*
[1]Tosio Kato, Ph.D., *Acting Assistant Professor of Mathematics.*
Charles H. Kraft, Ph.D., *Acting Assistant Professor of Mathematics.*
Ralph M. Lakness, Ph.D., *Assistant Professor of Mathematics.*
Lucien M. LeCam, Ph.D., *Assistant Professor of Mathematics.*
*Elizabeth L. Scott, Ph.D., *Assistant Professor of Mathematics.*
Bernard Sherman, Ph.D., *Acting Assistant Professor of Mathematics.*
Errett A. Bishop, M.S., *Acting Instructor in Mathematics.*
Marvin P. Epstein, Ph.D., *Instructor in Mathematics.*
Howard A. Osborn, Ph.D., *Instructor in Mathematics.*
[1]Marvin Rosenblum, M.A., *Acting Instructor in Mathematics.*
J. Paul Roth, Ph.D., *Instructor in Mathematics.*
[2]Howard G. Tucker, M.A., *Associate in Mathematics.*

Andrew Acrivos, Ph.D., *Instructor in Chemical Engineering.*
A. S. Besicovitch, F.R.S., *Visiting Professor of Mathematics for the spring semester.*
David Blackwell, Ph.D., *Visiting Professor of Mathematics.*
[2]Charles Loewner, Ph.D., *Visiting Professor of Mathematics.*
Hendrick S. Konijn, M.A., *Lecturer in Agricultural Economics.*
Joseph Putter, Ph.D., *Lecturer in Mathematics for the fall semester.*
Norman E. Steenrod, Ph.D., *Visiting Professor of Mathematics for the spring semester.*
Jan van der Corput, Ph.D., *Visiting Professor of Mathematics.*

Letters and Science List.—All undergraduate courses in mathematics except courses 7, 107, 142A, 142B, 142C, 142D, 144 are included in the Letters and Science List of Courses. For regulations governing this list, see page 7.

Departmental Major Advisers: Mr. Flanders, fall semester; Mr. Foster, spring semester; Mr. Lehmann (*Statistics*).

THE MAJOR IN MATHEMATICS

Preparation for the Major in Mathematics.—Advisers: Mr. Flanders, fall semester; Mr. Foster, spring semester.

Before taking the upper division courses for the major, the student is required to have a basis of knowledge equivalent to courses C, G, 8, 9, 3A–3B, 4A–4B. It is desirable, therefore, that he should have completed in high school two years of algebra, plane and solid geometry, and trigonometry, in order to anticipate as much of this work as possible.

The Major in Mathematics.—In the 24 units of upper division work required for the major in mathematics, the student is supposed to acquire com-

* Absent on leave, 1954–1955.
[1] In residence fall semester only, 1954–1955.
[2] In residence spring semester only, 1954–1955.

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petence in algebra, analysis, and geometry. The courses designed for this purpose are 111A–111B, 112A–112B, 119A–119B, in each of which at least 3 units should be taken. Courses 150A–150B, 185, or 201A–201B form a desirable part of the major program. The attention of those who are interested in logic is directed to Philosophy 12A–12B, as well as to Mathematics 109A–109B and 127A–127B. Courses in number theory, 115A–115B, and numerical analysis, 128A–128B (relating to large-scale digital computers), are also available.

The attention of the student is directed to the possibility of making group majors with other departments. Such majors will be welcomed not only with the departments of the physical sciences, but also with some of the social sciences and philosophy. Interested students should consult with the major adviser as early as possible.

Subject to the requirement of competence in the major, and with the approval of the adviser, the student is at liberty to take theoretical courses in physics, astronomy, or other sciences as part of his major in mathematics or mathematical statistics, as well as other upper division courses in mathematics. Course 201A–201B forms a desirable part of the program for senior students with facility for mathematics. Courses listed under Statistics may of course be used as part of the mathematics major. Special attention is directed also to the course in analytic mechanics, Physics 105A–105B. Students preparing for the Civil Service Examination in statistics should take course 132.

THE MAJOR IN MATHEMATICAL STATISTICS

Preparation for the Major in Mathematical Statistics.—Before undertaking the upper division program in statistics, the student should take course 12 and acquire a thorough knowledge of elementary calculus and algebra, with an emphasis on the conceptual side of the material offered. The recommended sequence of courses includes 3A, 3H, and 8 in the freshman year and 4G, 4H, and 12 in the sophomore year. When selecting the non-mathematical courses, the student should consider a suitable field of application of mathematical statistics such as astronomy, biological sciences, economics, physics, psychology or public health.

The Major in Mathematical Statistics.—In the 24-unit major the student should acquire substantial knowledge of statistics and probability, combined with a background in the theory of functions of real and of complex variables. To this end, the program should include courses 113, 120A, and at least 3 units in courses 120B, 132, 166. It is recommended that 120A, 120B be combined with 120C, 120D. In addition, the student should select any three of the courses 109, 111, 119, 150 and 185 and take at least three units in each.

Those contemplating graduate studies leading to higher degrees in statistics should make an effort to include in the major the undergraduate courses which are prerequisite to the graduate ones.

Attention of the student is drawn to the possibility of a group major in Statistics combined with an empirical science. This major includes courses 130A, 130B, 130C, 130D, and 132.

School of Business Administration.—Course 2, mathematics of finance and business, is a prerequisite for students in the School of Business Administration. As an alternative, however, course 16A–16B, analytic geometry and calculus, or course 3A–3B, plane analytic geometry and calculus, may be substituted, if students wish to continue with advanced mathematics.

Lower Division Courses

C. Trigonometry. (3) I and II. Mr. Osborn and the Staff

Prerequisite: plane geometry; one and one-half years of high school algebra or course D.

Course C includes plane trigonometry and spherical right triangles.

D. Intermediate Algebra. (3) I and II. Mr. Roth and the Staff

Prerequisite: one year of high school algebra. One and one-half years of high school algebra is advised. Not open to students who have received credit for two years of high school algebra, or course 3A or 8.

G. Solid Geometry. (2) I and II. ———

1. College Algebra. (3) I and II. Mr. Epstein and the Staff

Review and practice in general ideas and applications of algebra and trigonometry.

Open only to students who have had the prerequisite for course 3A, who have taken the qualifying examination for that course, and who are then permitted by the Department to enroll in course 1. Students who show little or no knowledge of algebra will not be allowed to enroll.

2. Mathematics of Finance and Business. (3) I and II. ——— and the Staff

Prerequisite: two years of high school algebra or course D. Prescribed in the School of Business Administration. Not open to students who have completed or are taking Engineering 120.

3A. Analytic Geometry and Calculus, First Course. (3) I and II. Mr. Sherman and the Staff

Prerequisite: two years of high school algebra or course D (passed with a grade of C or better), plane geometry, plane trigonometry.

All prospective registrants in Mathematics 3A, except those who have passed Mathematics D (with grade C or better) or Mathematics 1 in regular session at Berkeley the semester prior to registering in 3A, must take the qualifying examination which is given on Tuesday of registration week of each regular session.

Elements of differential calculus and analytic geometry.

3B. Analytic Geometry and Calculus, Second Course. (3) I and II. Mr. Pinney and the Staff

Prerequisite: courses 3A or 11A–11B, or 16A–16B.

Continuation of 3A. Analytic geometry, differential and integral calculus.

A special section is arranged for students who have taken a semester course of analytic geometry without calculus.

3H. Analytic Geometry and Calculus, Second Course. (3) I and II. Mr. Osborn

Prerequisite: course 3A with high attainment; admission on recommendation of the department.

Course substantially the same as 3B, but designed for students with special facility for mathematics.

3. Analytic Geometry and Calculus, First and Second Courses. (6) I and II. Mr. Bishop and the Staff

Prerequisite: same as for 3A including the qualifying examination, passed with higher attainment.

4A. Analytic Geometry and Calculus, Third Course. (3) I and II.

Prerequisite: course 3B. Mr. Protter and the Staff

Continuation of 3B. Thorough technique of differential and integral calculus.

4G. Analytic Geometry and Calculus, Third Course. (3) I and II. Mr. Lakness and the Staff

Prerequisite: course 3B or 3H with high attainment; admission on recommendation of the department.

Course substantially the same as 4A, but designed for students with special facility for mathematics.

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4B. Analytic Geometry and Calculus, Fourth Course. (3) I and II.
Prerequisite: course 4A. Mr. Flanders and the Staff
Continuation of 4A. Geometry and analysis of functions of several variables, partial derivatives, multiple integrals.

4H. Analytic Geometry and Calculus, Fourth Course. (3) I and II. ———
Prerequisite: course 4A or 4G with high attainment; admission on recommendation of the department.
Course substantially the same as 4B, but designed for students with special facility for mathematics.

4. Analytic Geometry and Calculus. Third and Fourth Courses. (6) II.
Prerequisite: same as for 4A. The Staff

8. Theory of Algebraic Equations. (3) I and II.
Mr. Epstein, Mr. Robinson
Prerequisite: two years of high school algebra (or course D) and course 3A.
Determinants, equations of third and fourth degrees, theory of equations.

9. Introduction to Projective Geometry. (3) I and II. Mr. Flanders
Prerequisite: course G or high school solid geometry, and course 8 or equivalent.
Projective theory of one-dimensional forms, point and line conics, mainly by the synthetic method.

*10. Spherical Trigonometry. (2) I. ———
Prerequisite: one and one-half years of high school algebra, or course D, and plane trigonometry. Not open to students who have credit in Astronomy 8.

12. Elements of Probability and Statistics. (3) I and II. (See Statistics, below.)

14A–14B. Calculus and Advanced Calculus. (5–5) Yr. ———
Prerequisite: course 3B.
Covers approximately the subject matter of courses 4A–4B, 110A–110B.

16A–16B. Analytic Geometry and Calculus. (3–3) Yr.
Mr. Bishop and the Staff
Prerequisite: two years of high school algebra or course D (passed with a grade of C or better), plane geometry, plane trigonometry.
A short course in analytic geometry and differential and integral calculus. Primarily for students in the College of Agriculture.

Related Course in Another Department

Logic. (Philosophy 12A–12B). (3–3) Yr.

Upper Division Courses

101A–101B. Elementary Mathematics for Advanced Students. (3–3) Yr.
Mrs. McDonald, Mr. Lakness
101A: Mr. Lakness; 101B: Mrs. McDonald.
Prerequisite: courses 4A–4B, 8, 9. Course 101A is not prerequisite to 101B.
Selected topics in algebra and geometry, with particular emphasis on historical development.
Designed for students who are preparing to teach mathematics in secondary schools.

* Not to be given, 1954–1955.

107. Mathematics in Secondary Schools. (2) I. Mrs. McDonald
Enhancing content through applications; coördination; survey of materials; analysis of present-day tendencies. For seniors and graduate students. This course will be accepted in partial satisfaction of the requirement in education for the Certificate of Completion of the teacher-training curriculum.

109A–109B. Mathematical Logic. (3–3) Yr. ———
Prerequisite: Philosophy 12A and course 3B or 8.
Elements of mathematical logic: sentential connectives, quantifiers, identity. Introduction into metalogical problems. Examples of formalized mathematical theories.
Boolean algebras: fundamental notions and postulates, vertification of identities, infinite operations, atomic elements, ideals, representation problem. Connections between logic and Boolean algebras.

110A–110B. Advanced Engineering Mathematics. (2–2) Yr. Beginning each semester. Mr. Acrivos, Mr. Chambré, Mrs. McDonald
Prerequisite: course 4A–4B. Primarily for students in engineering.
Conjugate functions, hyperbolic functions, Fourier series, differential equations.

110. Advanced Engineering Mathematics. Double Course. (4) II. The Staff
Prerequisite: same as for 110A–110B.

111A–111B. Algebra. (3–3) Yr. Beginning each semester.
Prerequisite: courses 4A–4B, 8. Mr. Hodges, Mr. Seidenberg
111A: Linear dependence, matrices, characteristic values, quadratic forms.
111B. Groups, theory of equations, introduction to Galois theory, elements of ring theory.

112A. Projective Geometry. (3) II. ———
Prerequisite: courses 4A–4B, 9, 111A.
Projective coördinates. Loci of the second order. Higher plane curves.

112B. Metric Differential Geometry. (3) I and II. Mr. Roth
Prerequisite: course 4A–4B. Course 112A is not prerequisite to 112B.
Vector analysis. Study of curves and surfaces in three dimensions.

113. Second Course in Probability and Statistics. (3) I and II. (See Statistics, below.)

114. Introduction to the Theory of Potential. (3) II. Mr. Evans
Prerequisite: 110A–110B or equivalent.
Newtonian and vector potential, differential operators, problems related to Maxwell's equations.

115A–115B. The Theory of Numbers. (3–3) Yr. Mr. Lehmer
Prerequisite: course 8.
Divisibility, congruences, theory of prime numbers, Diophantine analysis, partitions.

*117. Analysis of Mathematical Problems. (2) I. ———
Prerequisite: upper division standing in mathematics; intended primarily for honor students.
Methods of attack on mathematical problems, without respect to particular field.

* Not to be given, 1954–1955.

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*118. Analysis of Mathematical Problems. (2) II.

Prerequisite: upper division standing in mathematics; intended primarily for honor students.

Methods of attack on mathematical problems, without respect to particular field. Course 117 is not prerequisite to 118.

119A–119B. Differential Equations. (3–3) Yr. Beginning each semester. Mr. Chambré, Mr. Morse

Prerequisite: course 4A–4B, with honor grades; or 14A–14B; or 4A–4B and 110A–110B; or consent of instructor.

Differential equations and analysis. Numerical solutions of differential equations, general properties and special types of differential equations; Bessel functions and Legendre polynomials.

120A–120B. Theory of Probability and Statistics. (3–3) Yr. (See Statistics, below.)

*121. Mathematical Introduction to Economics. (3) I. Mr. Evans

Prerequisite: course 4A–4B.

Monopoly, competition, theory of dimension, taxation, utility, economic dynamics.

127A–127B. Foundations of Mathematics. (3–3) Yr. Mr. Robinson

Prerequisite: courses 3A–3B, 8, and Philosophy 12A or course 109A.

Elements of set theory: operations on sets; relations, functions, set-theoretical equivalence; cardinals, ordinals; ordering, well ordering; introduction into axiomatic foundations.

Elements of theoretical arithmetic: natural numbers; successive extensions—integers, rationals, real numbers; basic arithmetical operations; applications of continuity principle.

128A–128B. Numerical Analysis. (3–3) Yr.

(128A is equivalent of course formerly numbered 128.)

Prerequisite: course 110A or 119A. Course 128A is not prerequisite to 128B.

Practical aspects of computational methods, especially those of use in large-scale digital computers. Principles of coding and programming of computers. Analytical approximations. Finite difference methods applied to numerical integration and solution of algebraic and differential equations.

142A–142B. Life Contingencies. (3–3) Yr. (See Statistics, below.)

142C–142D. Laboratory Course in Life Contingencies. (1–1) Yr. (See Statistics, below.)

144. Population Statistics. (3) II. (See Statistics, below.)

150A–150B. Theory of Functions, First Course. (3–3) Yr. Beginning each semester. Mr. LeCam

Prerequisite: course 4B.

Through critical development of analysis: limit theorems, Jacobians, measure, generalizations of integral, complex, and real variables.

Designed primarily for students who will work for higher degrees in mathematics and statistics. It may be followed by course 255A or course 201B.

* Not to be given, 1954–1955.

185. Introduction to the Theory of Functions of a Complex Variable. (3) I and II. Mr. Chambré, Mr. Besicovitch

Prerequisite: course 119A or 150A.

Differentiability of complex functions. Cauchy's integral. Power series. Laurent series. Analytic continuation. Singularities of analytic functions. Residue theorem; applications to definite integrals. Conformal mapping. Fourier and Laplace transforms with applications. Concepts and theorems as well as manipulation will be stressed.

190A–190B. Survey of Algebra and Analysis. (3–3) Yr. Mr. Evans

For upper division and graduate students in social sciences, particularly economics, without college training in mathematics. Topics include elementary algebra, algebraic equations, matrices, differential and integral calculus, difference equations. Illustrations will be drawn from the social sciences, especially economics.

199. Special Study for Advanced Undergraduates. (1–5) I and II. Mr. Pinney in charge

Investigation of special problems under the direction of members of the department. In particular, this course offers an opportunity to students with facility for mathematics to anticipate some of the advanced courses by individual study.

TEACHERS' COURSE

*307. Coördination of Teaching of Mathematics. (2) I and II. Mrs. McDonald

Group discussion.

GRADUATE COURSES

(Concerning conditions for admission to graduate courses, see page 10)

201A–201B. Function Theory. (3–3) Yr. Mr. Epstein

Prerequisite: courses 111A, 119A–119B.

Point sets in Euclidean space, measure, generalizations of integral including Lebesgue and Lebesgue-Stieltjes integrals; classical theorems on the complex variables; application of real variable theory to complex variable.

Students with facility for mathematics may well take this course in the senior year. It includes the material of course 150A–150B.

205A–205B. Theory of Functions of a Complex Variable. (3–3) Yr. Mr. Evans

Prerequisite: course 201A–201B.

The theory of analytic functions and topics such as meromorphic functions, entire functions, modular functions, and Abelian integrals, analytic theory of differential equations, inequalities, etc., at the pleasure of the instructor.

210A–210B. Theory of Functions of a Real Variable. (3–3) Yr. Mr. Morse

Prerequisite: course 201A–201B.

Measure theory, metric spaces, topics such as functional analysis, calculus of variations, partial differential equations, potential theory, transfinite processes, expansions, according to the pleasure of the instructor.

211A–211B. Theory of Linear Operators. (3–3) Yr. Mr. Wolf

Prerequisite: courses 201A–201B and either 185 or 205A.

Linear operators in Hilbert and Banach spaces. Spectral decomposition theorem. Completely continuous operators. Integral equations. Additional topics selected by the instructor.

* Not to be given, 1954–1955.

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215A–215B. Topology. (3–3) Yr. Mr. Lewy
Convergence, compactness, completeness, function space topologies and metrization. Connectedness, local connectedness, the fundamental group, homology theories, duality and fixed point theorems.

220A–220B. Differential Equations. (3–3) Yr. Mr. Pinney
General theories, topics in ordinary and partial differential equations, boundary value problems. This course presupposes some knowledge of complex and real variable theory.

221A–221B. Logarithmic and Newtonian Potential. (3–3) Yr.
Prerequisite: course 201A–201B or equivalent. Mr. Lakness
Relation to distributions of mass, analysis of harmonic functions, tensor invariants in Euclidean and Riemannian metric spaces.

222A–222B. Advanced Differential Equations. (3–3) Yr. Mr. Protter
Prerequisite: courses 220A–220B and either 201A–201B or 150A–150B and 185.
Theory of initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations with emphasis on nonlinear equations.

*225A–225B. Metamathematics. (3–3) Yr. Mr. Henkin
Prerequisite: courses 109A–109B, 127A.
Formalized mathematical theories. Symbols, concatenation, formulas, sentences, derivability, axiomatic basis. Consistency and completeness. Notions of model and consequence—their relations to consistency and derivability. Application to formalized number theory. Truth and probability—their mutual relations. Introduction to the decision problem.

230A–230B. Algebraic Geometry. (3–3) Yr. Mr. Seidenberg
Theory of algebraic functions. Algebraic varieties; in particular, algebraic curves. Bezout's theorem. Branches of a curve. Linear series. Theorem of Riemann-Roch. Emphasis will be on algebraic methods.

235A–235B. Set Theory. (3–3) Yr. Mr. Tarski
Prerequisite: courses 109A, 127A–127B.
Fundamental notions and axioms. Sets, their families, rings, fields. Finiteness and infinity. Relations, functions, images. One-to-one correspondence, set-theoretical equivalence, cardinal numbers. Similarity of relations, relation numbers. Partial and simple order. Well-ordering, arithmetic of ordinals. Applications of set theory, selected topics.

*240A–240B. Differential Geometry. (3–3) Yr. ———
Differential geometry with tensor analysis. Intrinsic geometry of surfaces. Parallel displacement of Levi Civita. Riemannian geometry of n-dimensions. Non-Riemannian geometry of Weyl and others.

*245A–245B. Introduction to Modern Algebra. (3–3) Yr. Mr. Tarski
Prerequisite: courses 109A–109B, 111A–111B, and 127A.
General notion of an algebraic system. Subalgebras. Isomorphism. Homomorphism and equivalence relations. Direct products. Free algebras. Applications of general notions to special algebraic systems: groups, rings, fields, lattices, Boolean algebras.

250A–250B. Algebra. (3–3) Yr. Mr. Flanders
Prerequisite: course 111A–111B.
Topics in theory of fields, algebraic and transcendental extensions, Galois theory, valuations, ideal theory, representation theory.

* Not to be given, 1954–1955.

255A–255B. Probability Theory and Its Analytic Basis. (3–3) Yr. (See Statistics, below.)

255C–255D. Laboratory Course in Probability Theory and Its Analytic Basis. (1–1) Yr. (See Statistics, below.)

265A–265B. Advanced Probability. (3–3) Yr. (See Statistics, below.)

270. Technical Hydrodynamics. (3) II. ———
Theoretical analyses of motion of frictionless and viscous fluids, flow of compressible fluids at sub- and supersonic velocities.

290. Seminars. (2–6) I and II. The Staff (Mr. Lewy in charge)
Topics in foundations of mathematics, theory of numbers, numerical calculation, analysis, geometry, algebra, probability and theory of statistics, and in their applications, by means of lectures and informal conferences; work based largely on original memoirs. During 1954–1955 there will be, in particular, lecture seminars on the following subjects, in charge of the persons indicated:
(b) Selected topics in modern algebra. I, II, Mr. Epstein, Mr. Seidenburg; (c) Operators in Banach space and applied mathematics, I, II, Mr. Kato, Mr. Wolf; (e) Foundations and abstract algebra, I, II, Mr. Tarski; (f) Topics in partial differential equations, I, II, Mr. Protter; (g) Topics in calculus of variations and partial differential equations; I, II, Mr. Lewy; (j) Asymptotic expansions, I, II, Mr. van der Corput; (k) Functional analysis, I, II, Mr. Kelly; (l) Topics and problems of automatic computing, I, II, Mr. Lehmer.

295. Individual Research Leading to Higher Degrees. (2–6) I and II.
The Staff (Mr. Lewy in charge)

Mathematical Colloquium. (No credit) I and II.
The Staff (Mr. Wolf in charge)
Meetings for the presentation of original work by members of the staff and graduate students.

Statistics

Lower Division Courses

7. Mathematics for Insurance. (3) II. Miss Fix
Prerequisite: course 4A.
Compound interest. Annuities certain. Operations with actuarial symbols. Interpolation. Finite differences. Graduation of mortality tables. Summation. Numerical integration.

12. Elements of Probability and Statistics. (3) I and II.
Mr. Blackwell, Mr. Kelley, Mr. Neyman, Mr. Sherman
I. Mr. Sherman, Mr. Kelley; II. Mr. Blackwell, Mr. Neyman.
Prerequisite: two years of high school algebra or course D.
For students wishing to specialize in statistics as well as for those wishing to acquire basic concepts for general education. Relative frequency. Discrete probability. Testing statistical hypotheses. Illustrations from genetics, bacteriology, industrial sampling and public health.

Upper Division Courses

113. Second Course in Probability and Statistics. (3) I and II.
———, Mr. Scheffé
Prerequisite: courses 3A–3B or 11A–11B or 16A–16B, and course 12.
Continuation of course 12. Expectation, variance, correlation, regres-

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sion. Probability generating function. Weak law of large numbers. Elements of estimation. Cramér-Rao inequality. Basic ideas of confidence intervals. Applications.

120A–120B. Theory of Probability and Statistics. (3–3) Yr. Mr. Kraft
Prerequisite: courses 4A–4B, 150A (may be taken concurrently), and 113. Course 111A is prerequisite to 120B. It is recommended that 120C–120D be taken concurrently.
Continuation of course 113. Theorem of Laplace (univariate and multivariate). Asymptotic distribution of χ^2. General definition of probability. Calculus of probability densities. Likelihood ratio tests with applications. Distribution of χ^2, t and F. General linear hypotheses. Gauss-Markoff theorem. Elements of estimation, including confidence intervals.

120C–120D. Laboratory Course in Theory of Probability and Statistics. (1–1) Yr. Mr. Kraft in charge
May be taken in conjunction with course 120A–120B. Course 120C is not prerequisite to 120D.

128. Numerical Analysis. (3) I. (See Mathematics, above.)

130A–130B. Statistical Inference. (3–3) Yr. Mr. Jeeves
Prerequisite for 130A: two years of high school algebra or course D; prerequisite for 130B: 130A and 3A or 11A. It is recommended that 130C–130D be taken concurrently.
A first-year course. Not open for credit to students who have completed courses 12 and 113. Not more than one of the courses 130A, 130E, 130G may be taken for credit.
The basic concepts and principal tools of probability theory, hypothesis testing, and estimation, presented for students of natural and social sciences. While the conceptual and applicational aspects are treated carefully, the more difficult mathematical theorems are stated without proof.

130C–130D. Laboratory Course in Statistical Inference. (1–1) Yr. Mr. Jeeves in charge
May be taken in conjunction with course 130A–130B. Course 130C is not prerequisite to 130D.

130E. Statistical Inference for Engineers. (3) I and II. Mr. Scheffé
Lectures and laboratory.
Not open for credit to students who have completed courses 12 and 113. Not more than one of the courses 130A, 130E, 130G may be taken for credit.
Prerequisite: course 4A–4B or consent of instructor.
Essential elements of course 130A–130B with all of the applications and illustrations chosen from the field of engineering.

*130G. Statistical Inference for City Planning. (3) I. ———
Lectures and laboratory.
Not open for credit to students who have completed courses 12 and 113. Not more than one of the courses 130A, 130E, 130G may be taken for credit.
Prerequisite: two years of high school algebra or course D.
Essential elements of course 130A–130B with the applications and illustrations chosen from such fields as sampling from and growth of human populations.

* Not to be given, 1954–1955.

132. Descriptive Statistics. (3) II. Mr. Hodges
Lectures and laboratory.
Prerequisite: course 113 or 130A; and course 4A–4B, or grade of at least B in course 3A–3B or 11A–11B.
Collective and individual characters. Mathematical statistics as theory of collective characters. Means. Measures of dispersion. Frequency curves. Moments. Sheppard's corrections. Pearson curves. Curves of Charlier. Methods of fitting. Stochastic explanation of various distributions. Multivariate distributions. Static regressions and correlations. Applications.

142A–142B. Life Contingencies. (3–3) Yr. Miss Fix
Prerequisite: courses 12 and 113 or 130A and 130C. It is recommended that 142C–142D be taken concurrently.
Mortality tables and related functions. Laws of mortality. Annuities and assurances for one and more than one life. Policy reserves. Return of premiums. Rule of uniform seniority. Disability insurance. Some statistical applications of the mortality table. Survey of mortality tables.

142C–142D. Laboratory Course in Life Contingencies. (1–1) Yr. Miss Fix in charge
May be taken in conjunction with course 142A–142B.

144. Population Statistics. (3) II. Miss Fix
Prerequisite: courses 12 and 3A, or 130A.
Collection of data. Intercensal and postcensal populations. Formulas for mortality tables. Incompleteness of population data. Incompleteness of birth and death registrations. Infant mortality rates. Errors in age. Construction of mortality tables.

166. Sampling Surveys. (3) I. Mr. Putter
Prerequisite: Mathematics 12 or 130A or consent of instructor.
Recommended: course 113.
Mathematical theory of sampling. Best linear unbiased estimates and their variances. Sampling methods: unrestrictedly random, stratified and double sampling methods of Friedman-Wilcox. Sequential approach to stratification of the sample.

Graduate Courses

Courses 255A–255B and 260A–260B constitute the basis of graduate instruction for students whose primary interest is in theory. Similarly, courses 280A–280B, 281, and 261 represent the core of the graduate program for students interested in statistics as a tool in empirical research, either experimental or observational.

With the approval of the instructor, students engaged in empirical research may register in appropriate courses without the indicated prerequisites.

In addition to supervised practical work during the laboratory courses, the students registered in these courses will be able to use the laboratory at other times.

202A–202B. Theory of Probability and Statistics. (3–3) Yr. Mr. Jeeves
Prerequisite: 12 units of upper division mathematics with honor grades.
An advanced treatment of the material covered in courses 12, 113, 120A–120B, designed as a unique statistical prerequisite for course 260A–260B. It is recommended that course 202C–202D be taken concurrently.

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202C–202D. Laboratory Course in Theory of Probability and Statistics. (1–1) Yr. Mr. Jeeves in charge
It is recommended that course 202A–202B be taken concurrently. Course 202C is not prerequisite to 202D.

254. Generating Functions. (3) II. Mr. Besicovitch
Prerequisite: courses 150A–150B and 185.
Trigonometric integrals. Characteristic functions. Laplace transform. Mellin transform. Applications to difference equations.

255A–255B. Probability Theory and Its Analytic Basis. (3–3) Yr. Mr. Blackwell
Prerequisite: courses 150A–150B and 185. It is recommended that course 255C–255D be taken concurrently.
Basic concepts of measure theory: sets, measures, measurable functions, integrals. Axiomatic foundations of probability theory. Distribution functions and characteristic functions. Central limit problem; infinitely divisible laws. Strong laws of large numbers.

255C–255D. Laboratory Course in Probability Theory and Its Analytic Basis. (1–1) Yr. Mr. Blackwell in charge
Prerequisite: course 150A–150B and 185.
May be taken concurrently with 255A–255B. Illustrative examples in probability theory and applications to probability problems in various fields such as statistical physics.

256. Nonparametric Inference. (3) I. Mr. Lehmann
Prerequisite: course 260A.
Theory of some current tests. Asymptotic distribution theory. Unbiased and consistent point estimation. Theory of optimum rank tests and of tests based on permutation of observations. Tolerance and confidence limits.

258. Theory of Statistical Decision Functions. (3) I. Mr. Blackwell
Prerequisite: course 260A–260B.
Theory of statistical decision functions as a generalization of theories of tests and of estimation. Decision problems viewed as two-person zero sum games. Determinateness. Bayes solutions. Characterization of complete families and of minimax procedures. Applications to specific decision problems.

*259. Probability Models of Natural Phenomena. (3) II. ———
Prerequisite: course 260A–260B.
Relation between natural phenomena and their mathematical theory. Interpolation formula and structural model. Deterministic and stochastic models. Static stochastic models. Dynamic stochastic models. Problem of adequacy. Examples from astronomy, general biology, and economics.

260A–260B. Advanced Topics in Probability and Statistics. (3–3) Yr. Mr. Neyman, Mr. LeCam
Prerequisite: courses 111A, 120A–120B, and 150A–150B or 201A–201B, 185. Course 255A is prerequisite to 260B. It is recommended that 260C–260D be taken concurrently.
Continuation of course 120A–120B. Early principles of statistical tests. Testing simple hypotheses. Best similar and best invariant tests of composite hypotheses. Linear hypothesis. Confidence intervals. Introduction to multivariate statistical analysis. Sequential and nonparametric statistical analysis. Theory of point estimation.

* Not to be given, 1954–1955.

260C–260D. Laboratory Course in Advanced Topics in Probability and Statistics. (2–2) Yr. Mr. Neyman in charge
May be taken concurrently with course 260A–260B. Course 260C is not prerequisite to 260D.

261. Statistical Problems in Experimentation. (3) II. Mr. Scheffé
Lectures and laboratory.
Prerequisite: some familiarity with analysis of variance and consent of instructor.
Mathematical models of experimental problems. Random and systematic designs. Complex experiments. Randomized blocks. Latin and Graeco-Latin squares. Biological assay. Recent developments in the theory of experimental design.

*262. Statistical Inference in Relation to Stochastic Processes. (3) I. ———
Prerequisite: course 255A–255B and 260A–260B or consent of instructor.
Stochastic processes and certain types of hypotheses concerning them. Observable variables. Tests of hypotheses. Problems of estimation.

*263. Statistical Studies of Risks. (3) I. ———
Lectures and laboratory.
Prerequisite: course 130A–130B or 113.
Life and sickness tables. Standard error of a table. Law of Gompertz-Makeham. Standardization of rates of risk. Epidemiological and medical statistics. Theory of growth. Simple random processes explaining various population phenomena. Problems of social and commercial insurance.

*264. Statistical Problems of Mass Production and Control of Quality. (3) I. ———
Lectures and laboratory.
Prerequisite: course 113 or 130A or 130E.
Variability in manufactured products. Controlled accuracy of analyses and controlled variability of manufactured products. Sampling designed to protect interests of manufacturer and of consumer. Estimation of percentage defective. Identification of causes of defects.

*265A–265B. Advanced Probability. (3–3) Yr. ———
Prerequisite: course 255A–255B or consent of instructor.
Recent developments in the theory of probability. Stochastic processes. Markoff chains. Weak and strong central limit problems in the case of dependence.

267. Large Sample Theory. (3) II. Mr. LeCam
Prerequisite: course 260A.
General convergence theorems. Classical properties of maximum likelihood estimates. Regularly best asymptotically normal estimates and related tests, including the χ^2 test. Likelihood ratio and related tests.

269A–*269B. Recent Developments in the Theory of Statistics. (3–3) Yr.
269A: I and II. Mr. Lehmann
Prerequisite: courses 255A, 260A.
Recent developments in the theories of hypothesis testing, estimation, and multiple decisions.

* Not to be given, 1954–1955.

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280A. Advanced Statistical Inference. (3) I. Mr. Hodges

Prerequisite: course 130A–130B or consent of instructor. It is recommended that course 280C be taken concurrently.

Estimation and testing linear hypotheses. Simple experimental designs. Multiple comparisons. Variance components. Analysis of covariance. Illustrations adjusted to the interests of the audience in each year.

280B. Advanced Statistical Inference. (3) II. Mr. Hodges

Prerequisite: 280A or consent of instructor. It is recommended that course 280D be taken concurrently.

Nonparametric methods. Introduction to sequential analysis. Analysis of quantile response data. Illustrations adjusted to the interests of the audience in each year.

280C–280D. Laboratory Course in Advanced Statistical Inference. (1 or 2; 1 or 2) Yr. Mr. Hodges in charge

May be taken concurrently with courses 280A and 280B. Course 280C is not prerequisite to 280D.

281. Analysis of Discrete Observations. (3) I. Miss Fix

Prerequisite: course 130A–130B or course 120A–120B.

Discrete models. Discrete distributions and their limits. Transformations. Chi-square and other best asymptotically normal methods.

290M. Seminar on Statistical Problems in Engineering. (2–6) II. ———

Prerequisite: consent of instructor.

Correlation and regression studies. Pitfalls. Statistical design of cause-and-effect studies in engineering research.

*290P. Seminar in Probability. (2–6) I and II. ———

*290Q. Structure of Stochastic Processes. (2–6) II. ———

Prerequisite: consent of instructor.

The role of partial ordering in stochastic theories. Differences between random point functions and random set functions. Fourier analysis of time series.

290S. Statistical Seminar. (2–6) I and II. Mr. Neyman in charge

290W. Seminar on Statistical Problems in Economic and Agricultural Economics. (2–4) I. Mr. Konijn

Prerequisite: consent of instructor.

Statistical problems in the measurement of economic magnitudes and relations. Correlation and regression studies. Current research.

295S. Individual Research Leading to Higher Degrees. (2–6) I and II. The Staff (Mr. Neyman in charge)

Statistics Colloquium. (No credit) I and II. The Staff

Meetings for the presentation of original work by members of the staff and graduate students.

* Not to be given, 1954–1955.

MILITARY SCIENCE AND TACTICS

(Department Office, 149 Gymnasium for Men)

Thomas L. Waters, Colonel, Artillery; *Professor of Military Science and Tactics (Chairman of the Department).*

Arthur J. Hoeman, Lieutenant Colonel, Ordnance Corps; *Associate Professor of Military Science and Tactics.*

Clifton S. Lindsey, Lieutenant Colonel, Corps of Engineers; *Associate Professor of Military Science and Tactics.*

Thomas C. Malone, Lieutenant Colonel, Artillery; *Associate Professor of Military Science and Tactics.*

Glyn W. Pohl, Lieutenant Colonel, Infantry; *Associate Professor of Military Science and Tactics.*

Wilford B. Gratrick, Major, Ordnance Corps; *Associate Professor of Military Science and Tactics.*

Vaughn R. Moss, Major, Artillery; *Associate Professor of Military Science and Tactics.*

Glenn W. Pape, Major, Transportation Corps; *Associate Professor of Military Science and Tactics.*

Michael J. Di Salvo, Captain, Artillery; *Assistant Professor of Military Science and Tactics.*

Stephan J. Guss, Jr., Captain, Quartermaster Corps; *Assistant Professor of Military Science and Tactics.*

Kenneth M. Moore, Jr., Captain, Corps of Engineers; *Assistant Professor of Military Science and Tactics.*

William H. Schultz, Captain, Military Police Corps; *Assistant Professor of Military Science and Tactics.*

John E. Steinke, Captain, Signal Corps; *Assistant Professor of Military Science and Tactics.*

Clarence E. Wolfinger, Jr., Captain, Infantry; *Assistant Professor of Military Science and Tactics.*

William F. Magill III, First Lieutenant, Infantry; *Instructor in Military Science and Tactics.*

Lower Division Courses

The lower division or basic courses meet the requirement established by the Board of Regents for military training in the first and second undergraduate years. Enrollment is limited to students who are male citizens of the United States, able-bodied, and under twenty-three years of age at the time of initial enrollment. A first-year or second-year student claiming exemption because of noncitizenship, physical disability, age, or prior military service will present a petition to the Registrar on the prescribed form for such exemption. Pending action on his petition, the student will enroll in the course prescribed for his year and enter upon the work thereof. These courses consist of three hours of formal instruction per week for two academic years. Instruction is given in subjects common to all branches of the Army. Uniforms and textbooks, as required, are provided by the government and must be returned in good condition on completion of the course.

The A part of a course is not a prerequiste for the B part of a course in either basic or advanced Military Science and Tactics courses.