The City College
Undergraduate Bulletin
2003–2005

The City University of New York • Convent Avenue at 138th Street • New York, NY 10031

CCNY 2003-05

The College of Liberal Arts and Science

GENERAL STATEMENT

The aims of College of Liberal Arts and Sciences coursework are several: firstly, to develop the students of the College as broadly cultivated and intelligent citizens of the world in which they live; secondly, to impart to the students of the College a critical cast of mind that is agile in its reception of new ideas, and accustomed to the mastery of new skills; thirdly, to train students so that each may be able to perform some particular function in the community in a worthy and ethical manner. In attaining these goals, students fulfill requirements in a broad range of categories, such as art, literature, foreign language, social science, mathematics, and natural science.

ACADEMIC STANDARDS

The attainment of the high academic standards The City College requires entails more than the maintenance of a 2.00 G.P.A., a minimal expectation. Diligent attendance of classes, on-time arrival for each scheduled session, careful preparation for class, and timely completion of coursework are all significant factors in ensuring academic success. Perhaps, most importantly, is the insistence of the College on a strict academic integrity: any coursework submitted by a student should be the product of an independent analysis and synthesis that is based on the data of authorities in the field—not a word-for-word copying of published sources (see section on plagiarism in Appendix B).

UNDERGRADUATE MAJORS, DEGREES OFFERED

The College of Liberal Arts and Science (CLAS) offers courses of study leading respectively to the degrees of Bachelor of Arts, Bachelor of Science, Bachelor of Fine Arts, and to the combined B.A./M.A. within its divisions:

- **Humanities and Arts**
- **Science**
- **Social Science**

Undergraduate majors are offered in more than thirty-five fields. Advisors in the office of each academic Dean assist students in making their initial choices of majors and in reconsidering chosen fields of study. Some departments offer B.A./M.A. programs (see the City College *Graduate Bulletin*), and the faculty participate extensively in CUNY Ph.D. programs, whether based on the CCNY campus or at the Graduate School and University Center in midtown Manhattan.

DEGREE REQUIREMENTS

The degree requirements in the College of Liberal Arts and Science include:

1. The minimum number of credits required for the degree is 120 for anyone who registered Fall 1998 or later.
2. Students must attain a C average (minimum GPA of 2.00) for all coursework taken at City College.
3. Students must also have a C average (minimum GPA of 2.00) in their major.
4. Students must complete either a total of 84 credits or the final 32 credits at City College.
5. At least 60% of the credits for the major must be completed at City College.
6. All fees and fines must be paid prior to graduation.

Transfer Students

1. All valid liberal arts credits are transferable and will be credited toward Core requirements to the limits stated below.
2. Students who transfer fewer than twenty-four credits must meet the same Core course requirements as entering freshmen. Students with twenty-four or more credits accepted for transfer must meet minimum distribution requirements. Each student's total college program (credits accepted for transfer plus those earned at The City College) must include at least the following number of credits in each curriculum area.

Arts	3
Foreign Language*	6
Humanities	9
Science	6
Social Science	3

** Unless exempted on the basis of high school preparation*

3. In order to achieve a balanced college program consistent with the City College Core, students may be required to take a limited number of credits beyond these minimum distribution requirements. Specifically, students must have completed (1) at least six credits of courses with a global or non-western focus, and (2) a course

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Department of Mathematics

(DIVISION OF SCIENCE)

Professor Edward Grossman, Chair • Department Office: NAC 8/133 • Tel: 212-650-5346

GENERAL INFORMATION

The City College offers the following undergraduate and combined degrees in Mathematics:

B.A.
B.S.
B.A./M.A. (Combined Degree)

PROGRAMS AND OBJECTIVES

The Mathematics Department offers programs of study that enable students to prepare for graduate study in pure and applied mathematics, and careers in industry and education. Majors may choose to specialize in one of the following areas:

- Pure Mathematics
- Applied Mathematics
- Secondary School Education

Students enrolled in major programs in other departments can obtain a Minor in Mathematics by completing the requirements listed below.

HONORS

Students planning to attend graduate school in mathematics are urged to apply for admission to the department Honors Program, which may lead to a degree with honors. Candidates should see the departmental Honors Advisor no later than the beginning of their junior year to plan a program of study.

REQUIREMENTS FOR MAJORS

Pure Mathematics (B.A. or B.S.)

In addition to completing the calculus sequence (20100, 20200 and 20300), students must complete a minimum of nine courses of mathematics including the following:

Required Courses

Mathematics:

30800: Bridge to Advanced Math	3
32300: Advanced Calculus I	4
32400: Advanced Calculus II	3
32500: Advanced Calculus III	3
34600: Elements of Linear Algebra	3
One of the following:	4
34700: Elements of Modern Algebra (4 cr.)	
44900: Introduction to Modern Algebra (4 cr.)	

Elective Courses

Students must choose additional courses to complete the eight course minimum requirement from among the following:

Mathematics:

32800: Methods of Numerical Analysis (3 cr.)
34500: Theory of Numbers (3 cr.)
36000: Introduction to Modern Geometry (3 cr.)
36500: Elements of Combinatorics (4 cr.)
37500: Elements of Probability Theory (3 cr.)
37600: Mathematical Statistics (4 cr.)
39100: Methods of Differential Equations (3 cr.)
43200: Theory of Functions of a Complex Variable (4 cr.)
43400: Theory of Functions of a Real Variable (4 cr.)
43500: Partial Differential Equations, Integral Equations, Boundary Value Problems (4 cr.)
44300: Set Theory (4 cr.)
44400: Mathematical Logic (4 cr.)
46100: Differential Geometry (4 cr.)
46300: Topology (4 cr.)
47700: Probability Theory II (4 cr.)
47800: Mathematical Statistics II (4 cr.)
51100: Selected Topics in Pure Mathematics (4 cr.)
51200: Selected Topics in Classical Analysis (4 cr.)
51300: Selected Topics in Probability and Statistics (4 cr.)

Total Credits for Specialization **29-32**

Additional Requirements

Students are also required to fulfill a minor concentration of two advanced courses with mathematical content from an allied discipline (e.g., Physical Sciences, Computer Science, Philosophy, Economics or Engineering) to be approved by the Assistant Chair.

Applied Mathematics (B.S.)

In addition to the Calculus sequence 20100, 20200, 20300, students must complete eight required courses plus one of the specialization options.

Required courses

Mathematics:

34600: Elements of Linear Algebra	3
36500: Elements of Combinatorics	4
36600: Introduction to Applied Mathematical Computation	2
37500: Elements of Probability Theory	3
37600: Mathematical Statistics	4
37700: Applied Statistics and Probability	2
39100: Methods of Differential Equations	3
46700: Mathematical Modeling	3

Option 1: Statistics

Mathematics:

47800: Mathematical Statistics II	4

Option 2
Mathematics:
38100: Discrete Time Models in Financial Mathematics 3
38200: Continuous Time Models in Financial Mathematics 3

Total credits for Specialization 28-30

Secondary School Education (B.S.)

In addition to completing the calculus sequence (20100, 20200 and 20300), students must complete the Major requirements listed below. Pedagogical requirements for NYS certification are listed in the School of Education section of this *Bulletin*.

Math Requirements
30800: Bridge to Advanced Mathematics 3
32300: Advanced Calculus I 4
34500: Theory of Numbers 3
34600: Elements of Linear Algebra 3
36000: Introduction to Modern Geometry 3
37500: Elements of Probability Theory 3

One of the following two:
34700: Elements of Modern Algebra (4 cr.)
44900: Introduction to Modern Algebra (4 cr.)

Two of the following: 6-8
32400: Advanced Calculus II (3 cr.)
32500: Advanced Calculus III (3 cr.)
32800: Methods of Numerical Analysis (3 cr.)
34200: History of Mathematics (3 cr.)
34500: Theory of Numbers (3 cr.)
36500: Elements of Combinatorics (4 cr.)
37600: Mathematical Statistics (4 cr.)
38100: Discrete Models of Financial Mathematics (3 cr.)
38200: Continuous Time Models in Financial Mathematics (3 cr.)

Total credits for Specialization 29-31

ADDITIONAL REQUIREMENTS

All Mathematics majors must complete the following courses:
New Student Seminar unless exempt (0 cr.)
English 11000: Freshman Composition (3 cr.)
English 21000 or equivalent: Second Level Writing Course (3 cr.)
Core Curriculum for the intended degree
Speech 11100 (3 cr.) or pass the Speech Proficiency test.

In addition, all students must complete the following:

College Proficiency Examination: Pass the CPE after completing 45 but no more than 60 credits.

Proficiency in a Foreign Language: Students must complete either four years of foreign language in high school or a fourth semester-level course at City College (B.A.) or two years of foreign language in high school or a second semester-level course at City College (B.S.)

Mathemetics majors who plan to go to graduate school are advised to select a foreign language from among French, Russian, and German.

Writing Across the Curriculum: Three elective-level courses that are identified as requiring at least 3,500 words of writing. Courses designated with a (W) at the end of each course description fulfill this requirement.

For more information, please consult the chapter entitled *Degree Requirements* in the introduction to this *Bulletin*.

Grades: Mathematics majors must maintain at least a C average in all Mathematics courses above calculus. No advanced undergraduate course may be taken unless a C is obtained in all prerequisite courses (or permission is received from the Assistant Chair).

FOUR YEAR B.A./M.A. PROGRAM

Students enrolled in the Honors Program may, with the permission from the Honors Office and the graduate advisor in the Department of Mathematics, participate in a special course of study culminating in the simultaneous awarding of Bachelor's and Master's degrees in Mathematics in four years. Details for this special course of study are available from the Assistant Chair of Mathematics.

REQUIREMENTS FOR THE MINOR

Students enrolled in major programs in other departments can also obtain a minor in Mathematics by completing the following requirements:

Required courses
I. A calculus sequence through Math 20300
II. A total of twelve credits at the City College in 30000-level courses (excluding 30500), which includes one of the following:
34600: Elements of Linear Algebra (3 cr.)
39200: Linear Algebra and Vector Analysis for Engineers (3 cr.)

Electives for Non-Majors

Students wishing to take courses beyond 20300 are advised to consult with the Assistant Chair on the selection of appropriate courses.

ADVISEMENT

Assistant Chair, Majors Advisor
Professor Thea Pignataro
NAC 8/133; 212-650-5175

Undergraduate Advisors
Professor Joseph Bak
NAC 8/133; 212-650-5105
Professor Vickie Chuckrow
NAC 8/133; 212-650-5105

Graduate Advisor
Professor Thea Pignataro
NAC 8/133; 212-650-5175

Honors Advisor
Professor Jacob E. Goodman
NAC 6/280; 212-650-5141

Math Computer Laboratories Supervisor and Placement Advisor
Mr. Mark Turner
NAC 6/272; 212-650-5229

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EXEMPTION CREDIT

Students can earn exemption credit in any Mathematics course by taking an exemption examination arranged by the Assistant Chair's office. Exemption from the course is awarded for a grade of 70 or above; credit is granted for a grade of 80 or above. Students who have registered for a course or who have previously failed an exemption examination in a course may not take an exemption examination for that course. The Mathematics Department awards credit for the College Board Advanced Placement Examinations according to the following:

- AP Calculus (AB) score 4 or 5; credit for Math 20100 or 20500
- AP Calculus (BC) score 4 or 5; credit for Math 20100 and 20200 or 20500
- AP Calculus (BC) score 3; credit for Math 20100 or 20500
- AP Statistics; score of 3 or higher; credit for Math 17300

DEPARTMENTAL ACTIVITIES

The Mathematics Club is open to all mathematics majors. The club plans and organizes lectures, discussions and social functions.

The Mathematics Colloquium meets regularly for talks by invited guests as well as Department faculty.

Various seminars meet regularly and discuss selected topics in mathematics.

AWARDS AND ASSISTANTSHIPS

The Mathematics Department awards several medals and prizes to outstanding students.

The Belden Medal
To the student or students who complete the Advanced Calculus sequence with distinction.

The Israel E. Drabkin Memorial Award
To a promising mathematics student with broad cultural interests.

The Bennington P. Gill Memorial Award
To the most promising graduating senior committed to graduate study in Mathematics.

The Emil L. Post Memorial Award
To the graduating senior or seniors judged most promising in Mathematics.

The Harry Schwartz Fellowship
To a Mathematics Major who has shown promise in Mathematics.

In addition to the medals and prizes listed above, the Mathematics Department annually awards prizes to the students turning in the best final examinations in calculus or related courses over the preceding two semesters.

COURSE DESCRIPTIONS

INTRODUCTORY COURSES

There are two calculus sequences: Math 20100, 20200, and 20300; and Math 20500 and 20900. Entry to the above sequences is determined by the placement examination or completion of the course prerequisites.

Math 20500 and 20900 may be taken by students who do not intend to study more advanced mathematics (e.g. Biology, Economics, and Architecture majors and students in the Program for Premedical Studies). Students who seek a B.S. degree should check the requirements of their major to determine which calculus sequence is appropriate.

Math 20300 is a prerequisite for all advanced courses. After Math 20500, students may take 20200 with the permission of the Assistant Chair. Without prior approval by the Assistant Chair no credit is allowed for an introductory course if a more advanced course has previously been completed.

15000: Mathematics for the Contemporary World
Bombarded by statistics, assailed by advertisers and advocates of all persuasions, the average person needs mathematics to make sense of the world. This course aims to give students the tools needed to critically examine the quantitative issues of our times. Students will learn the basics of logical reasoning, the use of graphs and algebra to create quantitative models, and the role of statistics and probability in analyzing data. We will apply these ideas to assess the quantitative claims raised in contemporary case studies commonly discussed in the media. 3 HR./WK.; 3 CR.

17300: Introduction to Probability and Statistics
Descriptive statistics and frequency histograms; measures of location and dispersion; elementary probability; permutations and combinations; multiplication rule and conditional probability; Bayes' Theorem; independent events; random variables, expected values; applications to binomial, hypergeometric, uniform and normal distributions; the Central Limit Theorem; testing statistical hypotheses; correlation; linear regression and least squares. Prereq.: placement by the Department. Credit will be given for only one of the following courses: Math 17300, Eco 29500, Psy 21500, Soc 23100. 4 HR./WK.; 4 CR.

18000: Quantitative Reasoning
Investigation of the basis for elementary operations in concrete situations, diagrams, and symbolic representation. Understanding of, and problem-solving in, the following areas: numerical operations, ratios and percents, linear and exponential growth in situations, formulas, and graphs; rate of change; mensurational geometry; units, dimension, and scaling. Prereq.: placement by the Department. 4 HR./WK.; 3 CR.

18500: Basic Ideas in Mathematics
Problem solving, sets, operations with sets, functions, numerical systems with different bases, topics in number theory, probability and geometry. Includes writing exercises and collaborative work. This course is for potential education majors only. Prereq.: a grade of C or higher in Math 18000 or placement by the department.
4 HR./WK.; 3 CR.

19000: College Algebra and Trigonometry
Introduction to functions, rational expressions and their applications, rational exponents, conic sections, Gaussian elimination and determinants, nonlinear systems of equations, introductions to trigonometric functions. Prereq.: placement at college entry or by subsequent examination.
4 HR./WK.; 2 CR.

19500: Precalculus
Intervals, inequalities, operations on functions, inverse functions, graphing polynomial and rational functions, binomial theorem, exponential and logarithmic functions, trigonometric functions and formulas. Prereq.: a grade of C or higher in Math 19000 or placement by the department.
4 HR./WK.; 3 CR.

20100: Calculus I
Limits, derivatives, rules of differentiation, trigonometric functions and their derivatives, Newton's Method, differentials, graph sketching, maximum and minimum problems, related rates, introduction to integration, areas. Prereq.: grade of C or higher in Math 19500 or placement by the Department. Credit will be given for only one of the following courses: Math 20100 (part of sequence 20100, 20200, 20300) or 20500. 4 HR. LECT./WK.; 3 CR.

20200: Calculus II
Areas between curves; volumes of solids of revolution; integration of trigonometric, exponential and logarithmic functions, analytical and numerical methods of integration, improper and infinite integrals, conic sections, polar coordinates; parametric representation of curves, vectors in the plane. Prereq.: grade of C or higher in Math 20100 or placement by the Department. After completion of Math 20900, only 3 credits will be given for Math 20200. (Part of sequence 20100, 20200, 20300.)
4 HR. LECT./WK.; 3 CR.

20300: Calculus III
Vectors, infinite series, Taylor's theorem, solid analytic geometry, partial derivatives, multiple integrals with applications. Interpretations and calculations using *Matlab* software. Prereq.: Grade of C or higher in Math 20200 or placement by the Department. 4 HR./WK.; 1 HR LAB./WK.; 4 CR.

20500: Elements of Calculus
Limits, derivatives, rules of differentiation, differentials, graph sketching, maximum and minimum problems, related rates, exponential and logarithmic functions, differential equations, anti-derivatives, area, volume, applications to economics. Prereq.: grade of C or higher in Math 19500 or placement by the Department. Credit will be given for only one of the following courses: Math 20100 or 20500. (Recommended for Architecture and Economics majors.) 4 HR./WK.; 4 CR.

20900: Elements of Calculus and Statistics
Introduction to differential equations including numerical method,; qualitative analysis of solutions; phase plane analysis for systems; biological applications; analysis of univariate and bivariate data; regression and correlation; random variables; the normal, Poisson and binomial distributions; statistical inference. A spreadsheet program such as *Excel* is used throughout the course. Prereq.: Math 20500 or placement by the Department. (Part of sequence 20500, 20900 for Biology majors.)
4 HR./WK.; 4 CR.

ADVANCED COURSES

30500: Mathematics: Language and Symbol
Intended as a third course in the science CORE sequence for non-science majors, this course is built around the use of a graphing calculator. First, assumptions and meaning of the symbolism in arithmetic and elementary algebra are investigated. This viewpoint is used to introduce—in an accessible way—ideas in selected topics from number theory, geometry, calculus, dynamical systems theory and statistics. Prereq.: Science 10300 and Science 10400.
3 HR./WK.; 3 CR.

30800: Bridge to Advanced Mathematics
This course explores the logical and foundational structures of mathematics, with an emphasis on understanding and writing proofs. Topics include set theory, logic, mathematical induction, relations and orders, functions, Cantor's theory of countability, and development of the real number system. 3 HR./WK.; 3 CR.

32300: Advanced Calculus I
Sequences, properties of continuous functions, derivatives and differentials, functions defined by series, integrability and integrals, convergence of function sequences. Prereq.: Math 30800 or departmental permission. 4 HR./WK.; 4 CR.

32400: Advanced Calculus II
Sequences, continuity, and completeness in metric spaces, contraction mappings and fixed point theorems, applications to differential equations; Fourier analysis, differentiation in n-space. Prereq.: Math 32300 and 34600. (Part of sequence 32300, 32400, 32500.) 3 HR./WK.; 3 CR.

32500: Advanced Calculus III
Integration in n-space, implicit and inverse function theorems, change of variables in multiple integrals, vector fields, line and surface integrals, theorems of Green, Stokes, and Gauss. Prereq.: Math 32400 and 34600. (Part of sequence 32300, 32400, 32500.) 3 HR./WK.; 3 CR.

32800: Methods of Numerical Analysis
Solution of equations by iteration techniques; Lagrange and Newton interpolation, Neville's method, divided differences, cubic splines; numerical integration, Romberg integration; systems of linear equations and pivoting techniques; Runge-Kutta methods for initial value problems. Prereq.: Math 34600, or 39200, and knowledge of MATLAB or other high level programming language. Pre- or Coreq.: Math 39100.
3 HR./WK.; 3 CR.

34200: History of Mathematics
Historical development of mathematical ideas and methods in geometry, theory of numbers, algebra, and analysis. Prereq.: Math 20400. (W) 3 HR./WK.; 3 CR.

34500: Theory of Numbers
Divisibility, primes, fundamental theorem of arithmetic, congruences, number theory from an algebraic viewpoint, quadratic reciprocity, number theoretic functions, diophantine equations. Prereq.: Math 20400 or departmental permission. 3 HR./WK.; 3 CR.

34600: Elements of Linear Algebra
Vector spaces, basis and dimension, matrices, linear transformations, determinants, solution of systems of linear equations, eigenvalues, and eigenvectors. Prereq.: Math 20300; coreq.: Math 20300 and departmental permission. (After completion of Math 39200 only 2 credits will be given for Math 34600.) 3 HR./WK.; 3 CR.

34700: Elements of Modern Algebra
Sets, mappings, rings, isomorphisms, integral domains, properties of integers, fields, rational numbers, complex numbers, polynomials, groups. Prereq.: Math 20400 and 34600. With departmental permission, partial credit may be given for Math 44900 after completion of Math 34700. Recommended for prospective teachers and others who want a basic course in abstract algebra. 4 HR./WK.; 4 CR.

36000: Introduction to Modern Geometry
Logical deficiencies in Euclidean geometry, Euclid's parallel postulate, introduction to non-Euclidean geometry, the logical consistency of the non-Euclidean geometries, Hilbert's Axioms. Prereq.: Math 20400.
3 HR./WK.; 3 CR.

36500: Elements of Combinatorics
The three problems of combinatorics (existence, counting, optimization), basic counting rules, graph theory, generating functions, principles of inclusion and exclusion, pigeonhole principle, selected additional topics. Prereq.: Math 20300.
4 HR./WK.; 4 CR.

36600: Introduction to Applied Mathematical Computation
Calculus, linear algebra, elements of probability theory and combinatorics are examined through use of *Matlab*. Topics selected from symbolic and numerical problems in analysis; matrices, linear mappings, eigenvalues and applications; queueing theory; random numbers and simulations; graphics. Prereq.: Math 34600. 3 HR./WK.; 2 CR.

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37500: Elements of Probability Theory
Permutations and combinations, conditional probability, independent events, random variables, probability distributions and densities, expectation, moments, moment generating functions, functions of random variables, Central Limit Theorem, sampling, confidence intervals. Prereq.: Math 20300. 3 HR./WK.; 3 CR.

37600: Mathematical Statistics
The gamma, chi-square, T, F, and bivariate normal distributions; Central Limit Theorem; confidence intervals and tests of hypothesis; the Neymen-Pearson Theorem; likelihood ratio test; estimation; sufficiency, unbiasedness, completeness; the Rao-Blackwell Theorem; the Rao-Cramer inequality; the method of maximum likelihood; the chi-square test; introduction to the analysis of variance and regression. Prereq.: Math 37500. 4 HR./WK.; 4 CR.

37700: Applied Statistics and Probability
Introduction to *SPSS*; organization of data; various descriptive statistics such as measures of variability and location; categorical variables; sampling distributions with *SPSS*; statistical inference, linear regression models; regression analysis; analysis of variance; the jackknife methodology of computer based estimation, discriminant analysis, factor analysis, cluster analysis. Prereq.: Math 37600 or departmental permission. 3 HR./WK.; 2 CR.

38100: Discrete Models of Financial Mathematics
Definitions of options and exotic options on stocks, interests rates and indices; binomial trees; volatility and methods to estimate volatility; continuous models and Black-Scholes; hedging; bond models and interest rate options; spreadsheet methods and computational methods including difference methods and Monte Carlo simulations. Prereq.: Math 20200. 3 HR./WK.; 3 CR.

38200: Continuous Time Models in Financial Mathematics
Review of discrete time models and binomial trees. Cox, Ross, Rubinstein approach to the Black-Scholes model; Black-Scholes equation and option pricing formulae; Brownian motion and stochastic differential equations; Ito's calculus and Ito's lemma; stopping times; the heat equation; option pricing and the heat equation; numerical solution of parabolic partial differential equations; interest rate models; simulation and financial models. Prereq.: Math 38100 or departmental permission. 3 HR./WK.; 3 CR.

39100: Methods of Differential Equations
First order equations; higher order linear equations with constant coefficients, undetermined coefficients, variation of parameters, applications; Euler's equation, series solutions, special functions; linear systems; elementary partial differential equations and separation of variables; Fourier series. Prereq.: Math 20300. 3 HR./WK.; 3 CR.

39200: Linear Algebra and Vector Analysis for Engineers
Matrix theory, linear equations, Gauss elimination, determinants, eigenvalue problems and first order systems of ordinary differential equations, vector field theory, theorems of Green, Stokes, and Gauss. Prereq.: Math 20300; Pre- or coreq.: Math 39100. No specialization credit will be given for both Math 32500 and 39200. (After completion of Math 34600 only 2 credits will be given for Math 39200.) 3 HR./WK.; 3 CR.

43200: Theory of Functions of a Complex Variable
Cauchy-Riemann equations, conformal mapping, elementary, entire, meromorphic, multiple-valued functions, Cauchy integral theorems, series expansion. Prereq.: Math 32500. 4 HR./WK.; 4 CR.

43400: Theory of Functions of a Real Variable
Lebesgue measure and integration on the real line, differentiation of real functions and the relation with integration, classical L_p spaces. Prereq.: Math 32500. 4 HR./WK.; 4 CR.

43500: Partial Differential Equations, Integral Equations, Boundary Value Problems
First order equations, shock waves; classification and canonical forms of higher order equations, characteristics, the Cauchy problem for the wave equation: Huygens' principle; the heat equation; Laplace's equation; the Dirichlet and Neuman problems; harmonic functions; eigenvalue expansions; Green's functions. Prereq.: Math 32500 and 39100 or permission of the instructor. 4 HR./WK.; 4 CR.

44300: Set Theory
Axioms of Zermelo-Fraenkel set theory; relations functions, equivalences and orderings; cardinal numbers and cardinal arithmetic; well-ordered sets; ordinal numbers, transfinite induction and recursion; The Axiom of Choice and the Continuum Hypothesis. Prereq.: Math 32300 or permission of the instructor. 4 HR./WK.; 4 CR.

44400: Mathematical Logic
The propositional calculus, the sentential calculus, normal forms, first order theories, consistency, categoricity, decidability, Godel's incompleteness theorem, the Loewenheim-Skolem theorem. Prereq.: Math 32300, or permission of the instructor. 4 HR./WK.; 4 CR.

44900: Introduction to Modern Algebra
Groups, rings, fields. Prereq.: Math 32300 and 34600. With departmental permission, partial credit may be given for Math 44900 after completion of Math 34700. 4 HR./WK.; 4 CR.

46100: Differential Geometry
The theory of curves and surfaces in three-dimensional space: frames, fundamental forms, geodesics; curvature of surfaces; surface area; surfaces with boundary, the Gauss-Bonnet Theorem; introduction to Riemannian metrics. Prereq.: Math 32500 or permission of the instructor. 4 HR./WK.; 4 CR.

46300: Topology
A course in general topology. Sets of points on the real line and in general abstract spaces, relations between sets of points and between a set and the space containing it, operations with sets, open sets, countability, compactness, connectedness, maps, continuity, metric spaces, general topological spaces. Prereq.: Math 32500 or permission of the instructor. 4 HR./WK.; 4 CR.

46700: Mathematical Modeling
Problems from industry, mathematical models, process of mathematical abstraction, problem-solving techniques, application of solutions. Prereq.: Math 34600, 36600, 37500, 39100. 3 HR./WK.; 3 CR.

47700: Probability Theory II
Special topics in probability such as stochastic processes, Markov chains. Prereq.: Math 34600, 37500; pre- or coreq: Math 32500. 4 HR./WK.; 4 CR.

47800: Mathematical Statistics II
The multivariate normal distribution, multiple and partial correlation, regression and least squares, the analysis of variance. Prereq.: Math 34600 and 37600. 4 HR./WK.; 4 CR.

51100: Selected Topics in Pure Mathematics
Topics to be chosen from the areas of algebra, analysis, topology, geometry, and logic. Prereq.: to be determined by the instructor. 3 HR./WK.; 4 CR.

51200: Selected Topics in Classical Analysis
Topics to be chosen from applied mathematics and related fields. Typical subjects are: asymptotic methods, wave propagation, mathematical biology. Prereq.: Math 34600, 39100, and 32500, and other requirements to be determined by the instructor. 3 HR./WK.; 4 CR.

51300: Selected Topics in Probability, Statistics, and Operations Research
Topics to be chosen from the areas of probability, statistics, game theory, combinatorial analysis, etc. Prereq.: to be determined by the instructor. 3 HR./WK.; 4 CR.

HONORS AND SPECIAL COURSES

30100-400: Honors I-IV
Approval of Department Honors Advisor required. Credit flexible but usually 3 credits per term.

31000: Independent Study
A program of independent study under the direction of a member of the Department with the approval of the Assistant Chair. *Credit may be from 1-4 credits, as determined before registration by the instructor with the approval of the Assistant Chair.*

31100-2000: Selected Topics in Mathematics
Topics not covered in the usual department offerings. Topics vary from semester to semester, depending on student and instructor interest. Prerequisites as determined by the instructor.
Credits and hours will be determined by the instructor and the department, with a maximum of 4 credits per course.

GRADUATE COURSES OPEN TO UNDERGRADUATES

Qualified students may take, with departmental approval, any course available in the master's program in Mathematics or the first year of the doctoral program in Mathematics. These courses are described in the appropriate catalogs.

FACULTY

Ethan Akin, Professor
B.S., The City College; Ph.D., Princeton Univ.
Joseph Bak, Associate Professor
B.A., Yeshiva Univ., M.A., Ph.D.
Jacob Barshay, Professor
A.B., Princeton Univ.; M.A., Brandeis Univ., Ph.D.
Gilbert Baumslag, Distinguished Professor
B.S., Univ. of Witwatersrand (South Africa), D.Sc.; Ph.D., Univ. of Manchester (England)
Mark Brown, Professor
B.S., The City College, M.S.; Ph.D., Stanford Univ.
Isaac Chavel, Professor
B.A., Brooklyn College; M.S., New York Univ.; Ph.D., Yeshiva Univ.
Vicki Chuckrow, Associate Professor
B.S., The City College; M.S., New York Univ., Ph.D.
Sean Cleary, Assistant Professor
A.B., Cornell Univ.; Ph.D., Univ. of California (Los Angeles)
Jacob Eli Goodman, Professor
A.B., New York Univ.; A.M., Columbia Univ., Ph.D.
Noam Gordon, Associate Professor
B.S., Brooklyn College; M.A., Yeshiva Univ.; Ph.D., New York Univ.
Edward Grossman, Professor and Chair
A.B., New York Univ., Ph.D.
Joseph Grotowski, Associate Professor
B.S., Australian Nat'l Univ.; M.S., New York Univ., Ph.D.
Alberto Guzman, Professor
B.S., The City College; M.S., Univ. of Chicago, Ph.D.
Raymond Hoobler, Professor
A.B., Oberlin College; M.A., Univ. of California (Berkeley), Ph.D.
Karel M. Hrbacek, Professor
RNDr., Charles Univ. (Prague)
Jay Jorgenson, Professor
B.S., Univ. of Minnesota; M.S., Stanford Univ., Ph.D.
Lee Kaminetzky, Associate Professor
B.S.E., George Washington Univ.; M.S., New York Univ., Ph.D.
Stanley Kaplan, Professor
B.A., Cornell Univ.; Ph.D., Harvard Univ.
Ralph D. Kopperman, Professor
A.B., Columbia Univ.; Ph.D., M.I.T.
John Landolfi, Professor
B.S., Univ. of San Francisco; M.A., Brandeis Univ., Ph.D.
Michael Marcus, Professor
B.S., Princeton Univ.; M.S., M.I.T., Ph.D.
Alexei Miasnikov, Professor
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