modern America. Examination of speeches of Demosthenes, Pericles, Cicero, Burke, Webster, Lincoln, Churchill, Martin Luther King and others will be combined with study of theories of oratory and rhetoric from Aristotle to Wayne Booth. Major speeches from classical and modern drama and epic including Shakespeare, Milton and Melville will also be studied along with films and recordings of 20th-century political oratory. Speech writing and performance will form a practical component of this course. Second semester. Faggen

182. James Joyce.
In this seminar we will read the major writings of the Irish author James Joyce, whose work was immensely influential on all 20th-century literature, in English and in other languages. We will begin with his collection of short stories, *Dubliners*, and with his quasi-autobiographical novel, *A Portrait of the Artist as a Young Man*. The greater part of our class will be devoted to a detailed reading of *Ulysses*, his epic of the modern world. Time permitting, we will study excerpts of *Finnegans Wake* to establish strategies for reading this compendium of language and history. Second semester. Jaurretche

199. Independent Study in Literature.
Students who have the necessary qualifications and who wish to investigate an area of study not covered in regularly scheduled courses may arrange for independent study under the direction of a faculty reader. (See "Academic Policies and Procedures" for details.) First and second semester. Staff

MATHEMATICS AND COMPUTER SCIENCES

Mathematics is one of the greatest creations of the human mind and an essential part of human culture. It is also the quantitative language of the social, biological, and physical sciences. CMC offers a strong and versatile program in applied and theoretical mathematics. A solid technical sequence of computer science courses, stressing underlying scientific principles, complements the program. Interdisciplinary open problems arising in industry are the central component of mathematics clinics.

The major is taken by students interested in graduate studies in mathematics or preparing for careers in those areas of business, industry, and government where a sound knowledge and understanding of mathematics is necessary.

Students can combine the study of mathematics with a second field by completing a dual major. The mathematics-economics dual major is popular. Students can also major in mathematics with a computer science option, or complete the computer science sequence. Both choices ensure the attainment of computer skills appropriate for many career goals.

The CMC upper division mathematics curriculum benefits from a strong collaboration with the other Claremont Colleges and with the Claremont Graduate University.

Major Requirements

The major in mathematics requires ten courses in mathematics, distributed as follows:

1. **Basic Requirement: minimum of one course:**
   - **31. Calculus II (prerequisite course; does not count for major)**
   - **32. Calculus III**, or
   - **32H. Honors Seminar in Calculus III**
2. **Core Requirement of five courses***:*
   - **90. Linear Algebra**
   - **111. Differential Equations**
   - **131. Math Analysis I**
   - **151. Probability**
   - **171. Abstract Algebra,** or a proof-based substitute approved by the chair. Typical substitutes would be Number Theory or Group Theory.
3. **Level I Courses: two selected from the following:**

- **132. Math Analysis II**
- **135. Complex Variables**
- **152. Statistical Inference**
- **172po. Abstract Algebra II**
- **175. Number Theory**
- **185. Partial Differential Equations**

4. **Level II Courses: two courses:** Level II courses are all listed mathematics courses having as one of their prerequisites a Core Requirement or a Level I course (see listings above).

   Possible Level II courses include:
   - **109. Mathematics of Finance**
   - **112. Dynamical Systems**
   - **156. Stochastic Processes**
   - **187. Deterministic Operations Research,** and
   - **188. Game Theory**

Note: - *Computer Science 50. Introduction to Programming and Computer Tools*, or *60. Object-Oriented Programming with Applications* are highly recommended.

Senior Thesis in Mathematics

The senior thesis is a general education requirement and should serve as a capstone experience to a student's undergraduate education. Students must complete a senior thesis in at least one of their major areas under supervision of a faculty reader who teaches within that major, unless granted a special exception.

Students interested in doing a two-semester thesis project complete a one-half credit or full credit seminar or independent study project in the first semester and the senior thesis in the second semester. The senior thesis and any thesis seminar or independent study courses may not be counted as courses in the major. For further information on the senior thesis, see *Statement of Academic Policy*.

Special Options for Majors

Dual Major

The requirements for the mathematics part of a dual major are a minimum of eight mathematics courses distributed as follows:

1. **Core Requirement of four courses**:
   - **32. Calculus III**, or
     32H. Honors Seminar in Calculus III
   - **90. Linear Algebra**
   - **131. Math Analysis I**
   - **151. Probability**
2. **Four courses selected from:**
   - **109. Introduction to the Mathematics of Finance**
   - **112. Introduction to Dynamical Systems and Chaos**
   - **110. Introduction to Engineering Mathematics,** or
     111. Differential Equations
   - **132. Math Analysis II**
   - **135. Complex Variables**
   - **152. Statistical Inference**
   - **171. Abstract Algebra**
   - **185. Partial Differential Equations**

- **186. Stochastic Methods in Operations Research,** or
- **187. Deterministic Methods in Operations Research**
- **192 or 193. Mathematics Clinic**

Students with a dual major including mathematics are encouraged to write their *senior thesis* on a topic in mathematics. For further information, see "Senior Thesis in Mathematics" above.

Please note the restrictions on honors in the major for students with a dual major under "Honors in Mathematics" below. For further information on dual majors and the requirements for the other field of study of the dual major, please check the appropriate sections of this catalog.

Honors in Mathematics

To be considered for honors students must meet the College requirements for honors in the major. Students with a *dual major* in mathematics who wish to be considered for *honors* in mathematics will only receive honors if they:

- have completed all requirements for a *full major* in mathematics and are granted honors, or
- qualify and receive honors in *both fields* of their dual major. See "Honors in the Major" for details.

Mathematics Major With Computer Science Option

The requirements for a mathematics major with the Computer Science Option are:

1. **Basic Requirement** for mathematics majors (see above)
2. **Core Requirement** for mathematics majors (see above)
3. **Two courses from Level I Mathematics courses** (see above)
4. **Two upper division Computer Science** courses approved by the Department Chair

Notes: -Mathematics 50, Discrete Mathematics, is strongly recommended.

Computer Science Sequence

For information on the Computer Science Sequence, see the appropriate section of this catalog.

Notes: - Candidates for *Phi Beta Kappa* must complete *Mathematics 30* or higher for eligibility.

Advanced Placement, Credit, and Placement

The Mathematics Department grants placement and some credit for Advanced Placement examinations.

Students who earn a score of *5* on the *Calculus BC* exam are placed in Mathematics 32, and granted credit for Mathematics 30 - which completes the general education requirement in mathematics. Students who receive a score of *4* on the *Calculus BC* exam, or a score of *4 or 5* on the *Calculus AB* exam are placed by the department in an advanced calculus course and are eligible for retroactive credit for a lower level calculus course if they receive a grade of B+ (10.0) or better in the higher course in the freshman year. For further information, see "Academic Policies and Procedures."

Mathematics Placement Exams

All *new* students, except for students who have provided the registrar with official copies of AP test scores in calculus, take a *mathematics placement examination* prior to registration and the beginning of classes. The department offers several different placement exams, and new students will receive information on these exams during the summer. Through the placement

exams students are placed in one of the courses in the calculus sequence. Students who do not pass Exam 1 will be advised to take a pre-calculus course, either in Claremont or off-campus, in preparation for one of the courses meeting the general education requirement.

Study Abroad

All CMC students have the opportunity to apply for study abroad during the junior year. Because there are few programs in which a student can study mathematics abroad, and because many mathematics courses are sequential, students interested in studying mathematics abroad should consult with the chair of the Mathematics department no later than the beginning of their sophomore year to review course selections. The Mathematics department strongly recommends the "Budapest Semesters in Mathematics." This is a program in mathematics and computer science especially designed for American and Canadian undergraduates.

General Education Requirement Information

Courses meeting the college general education requirement in mathematics include: *Mathematics 30. Calculus I*, *Mathematics 31. Calculus II*, *Mathematics 32. Calculus III*, *Mathematics 32H. Honors Seminar in Calculus III*, and *Mathematics 50. Discrete Mathematics.* Several majors, including economics and the sciences, require or recommend completion of several mathematics courses. CMC students not ready to take a calculus course may take a pre-calculus course for credit towards graduation but not for the general education requirement in mathematics. Students who have received credit for a higher calculus course may not enroll for credit in a lower calculus course.

For the general education requirement in the *social sciences* and *the humanities*, CMC students majoring in mathematics must take designated courses in three of the fields of the social sciences (economics, government, history, and psychology), and in two of the four fields of the humanities (literature, philosophy, religious studies, and literature in a foreign language). Mathematics majors with a dual or double major in either the humanities or the social sciences will be required to take an additional course in those categories. For further information, see "Degree Requirements."

Courses in Mathematics and Computer Science offered at The Claremont Colleges

CMC students may take introductory calculus courses, equivalent to CMC's courses, at the other Claremont Colleges for the general education requirement in mathematics. Students placed in pre-calculus courses may take this course for credit at one of the other undergraduate colleges. The faculty of Claremont McKenna College, Harvey Mudd College, and Pomona College coordinate upper the upper division course offerings every year. Information on off-campus listings and descriptions may be obtained from the course schedules and catalogs of the individual colleges. A full major in computer science is available through the cooperative program in computer science of Harvey Mudd College and Pomona College.

The Faculty

Professors: Aksoy (on leave, second semester), Martelli (chair), Myhre, and Valenza; Associate Professors: Bradley, A. Lee (on leave, first semester), O'Neill, and Pinter-Lucke (on leave, second semeser); Assistant Professor: Aarão; Visiting Assistant Professors: Peterson, and Wilson

Courses

Mathematics

30. Calculus I.
Single variable calculus. Differentiation and integration of algebraic and transcendental functions with applications to the social and physical sciences. Prerequisite: Placement. First and second semester. Staff

31. Calculus II.
A continuation of Mathematics 30. Techniques and applications of integration; introduction to differential equations; improper integrals and indeterminate forms; infinite series and power series representation of a function. Applications to problems from the social and physical sciences. Prerequisite: Mathematics 30 or placement. First and second semester. Staff

32. Calculus III.
Multivariable calculus and vector analysis with applications to physical and social sciences. Functions of several variables; polar coordinates and parametric representation of curves; partial differentiation, the method of Lagrange multipliers; multiple integration; calculus of vector functions. Prerequisite: Mathematics 31 or placement. First and second semester. Staff

32H. Honors Seminar in Calculus III.
Open by invitation only to freshmen, this course is an introduction to rigorous mathematics for students having a substantial background and demonstrated interest in mathematics. The topics covered will be those of Calculus III with more emphasis on rigor and deeper understanding of the underlying mathematics. First semester. Aarao

50. Discrete Mathematics.
Topics include sets, propositional logic, combinatorics, recursion, trees, and graph theory, with emphasis on problems solving and proofs. Possible additional topics include analysis of algorithms, particularly search and ordering algorithms, and matrix theory. Prerequisite: Placement Test 1. First semester. Aarao

90. Linear Algebra.
An introduction to the methods of linear algebra with applications to the physical and social sciences. Topics will include: Linear equations and matrices, determinants, vector spaces, linear transformations, inner product spaces and quadratic forms, eigenvalues and eigenvectors, and canonical forms. Prerequisite: Mathematics 32. First semester. Martelli. Second semester. Staff

105. Discrete and Continuous Mathematical Modeling.
Basic modeling, discrete deterministic models, discrete stochastic models, stages, states and classes, empirical modeling, continuous models, continuous stochasticity. Prerequisite: Mathematics 31. (Not offered in 2004-2005.)

109. Introduction to the Mathematics of Finance.
This course emphasizes the math used in the valuation of derivative securities. Topics will include among others partial differential equations (diffusion equation), mathematical modeling of financial derivatives (calls, puts, etc.), and numerical methods for solving differential equations. These topics will aim at understanding the Black-Scholes Model. Prerequisite: Mathematics 90, or permission of instructor. Second semester. Aarao

110. Introduction to Engineering Mathematics.
Ordinary differential equations, line and surface integrals, elementary linear algebra, systems of different equations, and Fourier analysis. Continuous modeling with applications to mechanics; electricity and magnetism, heat, and sound. Prerequisite: Mathematics 32. (Not offered in 2004-2005.)

111. Differential Equations.
An introduction to the general theory and applications of differential equations. Linear systems, nonlinear systems, and stability. Prerequisite: Mathematics 32. (Students may not receive credit for both Mathematics 110 and 111.) First and second semester. Bradley

112. Introduction to Dynamical Systems and Chaos.
Qualitative analysis of discrete dynamical systems in dimension one and higher is motivated and presented with examples taken from the recent research literature. These include mathematical models of biological processes, such as the 1988 Siphonius fillyreae – ash whitefly – infestation in Southern California and its control with Hymenoptera Aphelinidae, and the Hopfield model of Neural Networks. Quantitative analysis of the systems is performed using the symbolic manipulator Maple. Prerequisite: Mathematics 32. First semester. Martelli

131. Math Analysis I.

Countable sets, least upper bound, and metric space topology including compactness, completeness, connectivity, and uniform convergence. Related topics as time permits. Prerequisite: Mathematics 90. Offered jointly by CMC and Pomona College. First semester. Aksoy

132. Math Analysis II.
A rigorous study of calculus in Euclidean Spaces including Riemann Integrals, derivatives of transformations, and the inverse function theorem. Prerequisite: Mathematics 131. Offered jointly by CMC and Pomona College. (Not offered in 2004-2005.)

135. Complex Variables.
An introduction to the theory and application of analytic functions of a complex variable. Prerequisite: Mathematics 90, or permission of the instructor. Offered jointly by CMC and Pomona College. Second semester. O'Neill

137. Real Analysis I.
Abstract measures, Lebesque measure, on Rn, and Lebesgue-Stieljes measure on R. The Lebesgue integral and limit theorems. Product measures and the Fubini Theorem. Additional related topics as time permits. Prerequisites: Mathematics 131, and 132. Offered jointly by CMC, Claremont Graduate University, and Pomona College. (Not offered in 2004-2005.)

138. Real Analysis II.
Continuation of Mathematics 137. Some of the topics covered will be: Banach and Hilbert spaces, Lp spaces, complex measures and Radon-Nikodym theorem. Prerequisite: Mathematics 137. Offered jointly by CMC, Claremont Graduate University, and Pomona College. (Not offered in 2004-2005.)

144. Fourier Analysis.
Fourier series and integrals. Questions of convergence, divergence and approximation. Applications to differential equations, the Dirichlet problem, moment problems, signal processing, probability and statistics. Prerequisite: Mathematics 131. First semester. O'Neill

151. Probability.
Discrete and continuous random variables, conditional and marginal distributions, independence, expectations, generating functions, transformations, central limit theorem. Applications to the social and physical sciences. Pre- or co-requisite: Mathematics 90, or permission of instructor. Offered jointly by CMC and Pomona College. First semester. Myhre

152. Statistical Inference.
Introduction to statistical inference including practical problems in the social and physical sciences. Estimation of parameters, confidence intervals, and tests of hypothesis. Prerequisite: Mathematics 151. Offered jointly by CMC and Pomona College. Second semester. Myhre

153. Advanced Topics in Statistical Inference.
Selected topics in statistical inference including Bayesian Inference, sequential procedures, and distribution free methods. Prerequisite: Mathematics 152. Offered jointly by CMC and Pomona College. (Not offered in 2004-2005.)

156. Stochastic Processes and Modeling.
Stochastic processes are ways of mathematically modeling dynamic relationships of sequences of random events. The course covers topics chosen from theory of discrete and continuous Markov chains, second order processes, renewal processes, martingales, Brownian motion, branching processes, random sums, ergodic theory and stationary processes. Stochastic models are basic to understanding many areas of the natural and physical sciences, and to analyzing the uncertainties affecting managerial decisions and the theory of the mathematics of finance. Applications of the theory of stochastic processes to these areas are given. Prerequisite: Mathematics 151. Offered jointly by CMC and Pomona College. First semester. Myhre

158. Applied Statistics.
An introduction to basic probability theory and the techniques for statistical inference. The course will be developed from problems and data sets provided by business, industry and government. Data sets will be analyzed in terms of standard techniques including data analysis, point and interval estimation, and tests of hypotheses including goodness of fit tests. In accordance with the requirements of the data sets, further techniques will be selected from the general areas of non-parametric statistics, Bayesian statistics, and analysis of variance. Statistical software packages will be used. Prerequisite: Mathematics 31, or permission of the instructor. (Not offered in 2004-2005.)

170. Finite Fields and Applications.
Designed to appeal to students in mathematics, computer science, and electrical engineering, the course will introduce students to the elementary theory of finite fields, as well as an introduction to

more basic algebraic structures, such as groups and rings. Students will also be exposed to some of the more common applications of finite fields in coding theory, cryptography, computational complexity, and finite geometry. (Not offered in 2004-2005.)

171. Abstract Algebra.
An introduction to the fundamental structures of abstract algebra, including groups, rings, fields, vector spaces, and modules; polynomial and field extensions; applications to number theory. Prerequisite: Mathematics 90. Offered jointly by CMC and Pomona College. Second semester. Wilson

175. Number Theory.
Properties of integers, congruences, Diophantine problems, quadratic reciprocity, number theoretic functions, primes. Prerequisite: Mathematics 131, or 171, or permission of instructor. Offered jointly by CMC and Pomona College. (Not offered in 2004-2005)

185. Partial Differential Equations.
Fourier Series, Fourier Transforms, Distributions. Partial Differential Equations: Heat, Wave, Laplace's, Transport, Schr?dinger, Black-Scholes. Reaction-diffusion equations, solitons, and numerical methods. Prerequisites: Mathematics 90, and 111. Second semester. Aarao

186. Stochastic Methods in Operations Research.
Simulation Theory, Stochastic models of inventory, reliability, queuing, sequencing, and transportation. Applications of these models to problems arising in industry, government, and business. Prerequisite: Mathematics 151. Cooperative course, offered jointly by CMC, Claremont Graduate University, Harvey Mudd College, and Pomona College. (Not offered in 2004-2005.)

187. Deterministic Methods in Operations Research.
Linear, integer, nonlinear, and dynamic programming. Applications to problems primarily in the social sciences; transportation problems, inventory analysis, classical optimization problems, and network analysis, including project planning and control. Prerequisites: Mathematics 32 and 90. Cooperative course offered jointly by CMC, Claremont Graduate University, Harvey Mudd College, and Pomona College. (Not offered in 2004-2005.)

188. Mathematics of Game Theory.
Games in extensive form, combinatorial games, strategic equilibrium, matrix games, and minimax theorem, computation of optimal strategies, cooperative and non-cooperative solutions of bi-matrix games, coalitional games and the core, indices of power, bargaining set, nonatomic games. Prerequisite: Mathematics 90; recommended: Mathematics 151. Not open to students who have completed *Economics 129. Game Theory*. Second semester. O'Neill

192, 193. Mathematics Clinic.
Applied mathematical modeling of current unsolved problems proposed by government and industry. Students will work together in small groups under faculty direction and will have contact with the industry or governmental agency for which the mathematical solution is relevant. Prerequisite: Permission of the instructor. Second semester. Myhre

199. Independent Study in Mathematics or Computer Science.
Students who have the necessary qualifications and wish to investigate an area of study not covered in regularly scheduled courses may arrange for independent study under the direction of a faculty reader. (See "Academic Policies and Procedures" for details.) First and second semester. Staff

Computer Science

50. Introduction to Programming and Computer Tools.
This course uses the programming language Java to introduce the fundamental notions of programming and small-scale software development. Specific topics include: data types and associated operations; control structures and basic algorithms; fundamentals of input/output; functions (class methods); error and exception handling; file-based input/output; an introduction to classes, class hierarchies, packages, and object-oriented programming; selected advanced topics. First semester. Pinter-Lucke. Second semester. A. Lee

60. Object-Oriented Programming with Applications.
A first course in object-oriented programming, using the language C++. Topics include: basics of C (program structure, preprocessor directives, data types, control structures, input/output, operators and subprograms); fundamental concepts of object-oriented programming: encapsulation, polymorphism, and inheritance; classes: member variables and functions (private and public), constructors and destructors; pointers and references; function and operator overloading; inheritance and multiple inheritance:

base, derived, and virtual base classes with access control; C++ input/output; virtual functions; applications; nonnumerical algorithms and data types; special topics according to the interests of students. Prerequisite: Computer Science 50 or equivalent. (Not offered in 2004-2005.)

70. Numerical Algorithms.
An introduction to numerical algorithms using the language Fortran. Topics include: a comprehensive introduction to Fortran; computer representation of numbers; an introduction to error analysis; numerical solution to linear and nonlinear equations; interpolation and extrapolation, numerical integration, and numerical solution to differential equations; incorporation of numerical libraries; modeling, and simulation. Prerequisites: Mathematics 31 and Computer Science 50. (Not offered in 2004-2005.)

80. Nonnumerical Algorithms.
Fundamental abstract data structures and algorithms, with emphasis on object-oriented implementation. Topics include: introduction to algorithm analysis; sorting and searching; string processing and abstract pattern matching machines; finite state machines; basic graph algorithms; and introduction to complexity theory and NP-completeness. Prerequisite: Computer Science 60. Second semester. A. Lee

85. Global Networks: Theory and Practice.
This course is designed to give students an understanding of the Internet and the World Wide Web. Topics will include the history and current structure of the Internet and the Web; construction of a basic Web page; the use of electronic bulletin boards for research and electronic indexing; electronic search engines and their algorithms and heuristics; hypertext markup language and the production of hypertext documents; standard graphical and sound formats for hypermedia; publication of a World Wide Web server; the design and implementation of Web applications. Prerequisite: Computer Science 50. Computer Science 60 recommended. (Not offered in 2004-2005.)

90. Systems Architecture.
The hardware and software architecture of contemporary computer systems: views of a system and multilevel machine organization; processors and memory; digital logic, microprogramming, and the conventional machine level; introduction to operating systems: functions and design; virtual memory systems; assembly language; distribution computing; networking and telecommunications. Prerequisites: Computer Science 50 and 60. First semester. Pinter-Lucke

95. Encryption and Encoding.
The theory and practice of data encoding and encryption, with much of the necessary mathematical background developed in the course. Topics include: an introduction to finite algebraic structures; residue arithmetic and the Chinese Remainder Theorem; basic notions of encoding and error correcting capabilities; complexity-theoretic foundations of cryptography; one-way and trapdoor functions; secret key and public key encoding: the Data Encryption Standard, the RSA algorithm; the factorization problem: elementary algorithms and the quadratic sieve method; theory of zero-knowledge protocols. Prerequisite: Mathematics 90; Computer Science 50 or equivalent recommended. (Not offered in 2004-2005.)

100. Software Development: Theory and Practice.
An introduction to software development methodologies, leading to the design and implementation of one or more substantial applications; the emphasis is on small systems environments. Topics include: a survey of software design and implementation methodologies; modern software development environments. object-oriented techniques; the incorporation of class libraries in applications development; automated documentation and configuration control debugging tools; design of graphical user interfaces; small-to-medium scale applications graphical database design and implementation. Prerequisites: Computer Science 50, 80, and 90. (Not offered in 2004-2005.)