

Mathematics and Computer Science

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.

The major in mathematics 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: five courses:**
 - 60. **Linear Algebra**
 - 111. **Differential Equations**
 - 131. **Math Analysis I**
 - 151. **Probability**
 - 171. **Abstract Algebra**, or a proof-based substitute approved by the chair (for example Mathematics 175. Number Theory)
3. **Level I Courses: two selected from the following:**
 - 132. **Math Analysis II**
 - 134. **Functional Analysis and its Applications**
 - 135. **Complex Variables**
 - 139. **Fourier Analysis**
 - 152. **Statistical Inference**
 - 173. **Advanced Linear Algebra**
 - 175. **Number Theory**
 - 182. **Partial Differential Equations**
4. **Level II Courses: two courses.**
Level II courses are all CMC mathematics courses with a Core Requirement or a Level I course (see listings above) as a prerequisite, including:
 - 109. **Introduction to the Mathematics of Finance**
 - 112. **Introduction to Dynamical Systems and Chaos**
 - 156. **Stochastic Processes and Modeling**
 - 187. **Deterministic Operations Research, and**
 - 188. **Mathematics of Game Theory**

Note:

- *Mathematics 149. Special Topics in Mathematics*, may be considered a Level I or a Level II course, depending on the topic in any given semester. It will be up to the department chair to determine if Mathematics 149 can be used for a major requirement.

Senior Thesis in Mathematics

The senior thesis is a general education requirement and the capstone experience of a student's undergraduate education. Students must complete a senior thesis in at least one of their majors under supervision of a faculty reader who teaches within that

major, unless granted a special exception.

Students interested in a two-semester thesis project complete a one-half credit or full credit thesis research course in the first semester and the senior thesis in the second semester. The senior thesis and the thesis research course may not be counted as courses in the major.

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
- 60. Linear Algebra
- 131. Math Analysis I
- 151. Probability

2. Four courses selected from the list provided below. At least *two groups* must be represented in the selection.

- **Group 1 (Theoretical Mathematics)**
 - 132. Math Analysis II, or
134. Functional Analysis and its Applications
 - 135. Complex Variables
 - 137. Real Analysis I
 - 138. Real Analysis II
 - 139. Fourier Analysis
 - 171. Abstract Algebra
 - 173. Advanced Linear Algebra
 - 175. Number Theory
- **Group 2 (Applied Mathematics)**
 - 105. Stochastic and Deterministic Modeling
 - 109. Introduction to the Mathematics of Finance
 - 111. Differential Equations
 - 112. Introduction to Dynamical Systems and Chaos
 - 182. Partial Differential Equations
 - 188. Mathematics of Game Theory
- **Group 3 (Computer Science)**
 - CS 51. Introduction to Computer

- Science
- CS 52. Fundamentals of Computer Science
- CS 62. Data Structures and Advanced Programming
- CS 76. Encryption and Encoding
- CS 81. Computability and Logic
- CS 105. Computer Systems
- CS 121. Software Development
- CS 131. Programming Languages
- CS 133. Database Systems
- CS 135. Distributed Software Architecture
- CS 140. Algorithms
- **Group 4 (Statistics)**
 - 152. Statistical Inference
 - 153. Advanced Topics in Statistical Inference
 - 158. Applied Statistics
 - 186. Stochastic Methods in Operations Research
 - 187. Deterministic Methods in Operations Research

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* including mathematics who wish to be considered for *honors* in mathematics are eligible if they:

- have completed all requirements for a *full major* in mathematics and are granted honors, or
- qualify and receive honors in *both disciplines* of their dual major. See

“Academic Honors at Graduation” 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

The Robert Day Scholars Program

The Robert Day Scholars Program identifies students with significant leadership aptitude and strong analytical skills, and cultivates those characteristics through completion of specific coursework and participation in co-curricular activities. The curricular focus is on finance, along with complementary coursework in economics, accounting, and organizational psychology. Robert Day Scholars receive a generous fellowship toward tuition, access to networking opportunities, and customized support from a career services specialist.

There are two parts of the Robert Day Scholars Program—an *undergraduate honors program for seniors*, and a *one-year Master of Finance program*. Students apply as juniors to become Robert Day Scholars in their senior year, and as seniors for the Master of Finance program. Interested students are encouraged to complete the prerequisites prior to their senior year. Please contact the Executive Director of the Robert Day School of Economics and Finance for additional information and refer to the website: www.cmc.edu/rdscholars. For further information on applications to the programs, see “Admission to Claremont

McKenna College;” program requirements and prerequisites are detailed in “Special Academic Programs.”

Computer Science Sequence

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

Scientific Modeling Sequence

The sequence in Scientific Modeling is a new program offering computational tools for modeling and program solving. Modeling and simulations offer an approach which will help students investigate a wide range of problems and at the same time take advantage of the ever increasing power of computers. The sequence is designed for students majoring in biology, chemistry, physics, management engineering, neuroscience and mathematics. Completion of the sequence will be noted on students’ transcripts. Professors A. Lee and Higdon are the academic advisors for this program. For detailed information on the requirements of the Scientific Modeling Sequence, see the “Scientific Modeling Sequence” section under *Joint Science* of this catalog.

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. They are eligible for *retroactive credit* for Mathematics 31 upon completion of Mathematics 32 with a grade of B+ (10.0) or better in the freshman year.

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* 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. Students who have received credit for a higher calculus course may not enroll for credit in a lower calculus course. 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. The placement exam may be taken on line. 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

Mathematics requirement: 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.* 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. Several majors, including economics and the sciences, require or recommend completion of one or more advanced mathematics courses.

Mathematics majors: 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

The faculty of Claremont McKenna College, Harvey Mudd College, and Pomona College coordinate the upper division course offerings in mathematics and computer science every year.

Information on off-campus listings and descriptions may be obtained from the course schedules and catalogs of the individual 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; it does not meet the general education requirement.

A full major in computer science is available through the cooperative program in computer science with Harvey Mudd College; interested students may complete a dual or full major at Pomona College.

The Faculty

CMC Faculty: Aksoy (on leave, first semester; chair, second semester), G. Bradley, Fukshansky, German, A. Lee, O'Neill (chair, first semester), Pinter-Lucke, and Valenza.

Visiting Faculty: Jedwab, Nelson, O'Brien, Peterson, and Stough.

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Courses

MATHEMATICS

30. Calculus I. *Staff*

Single variable calculus. Differentiation and integration of algebraic and transcendental functions with applications to the social and physical sciences. Prerequisite: Placement. Offered every semester.

31. Calculus II. *Staff*

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. Offered every semester.

32. Calculus III. *Staff*

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. Offered every semester.

32H. Honors Seminar in Calculus III. *Nelson*

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. Offered every fall semester.

50. Discrete Mathematics. *G. Bradley, Valenza*

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. Offered every semester.

60. Linear Algebra. *Aksoy, G. Bradley, Fukshansky*

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. Offered every semester.

105. Stochastic and Deterministic Modeling. *Staff*

Basic modeling, discrete deterministic models, discrete stochastic models, stages, states and classes, empirical modeling, continuous models, continuous stochasticity. Prerequisite: Mathematics 31. Offered every other year.

109. Introduction to the Mathematics of Finance. *German*

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 32. Offered every year.

111. Differential Equations. *G. Bradley*

An introduction to the general theory and applications of differential equations. Linear systems, nonlinear systems, and stability. Prerequisite: Mathematics 32. Offered every semester.

112. Introduction to Dynamical Systems and Chaos. *Staff*

Qualitative analysis of discrete dynamical systems in dimension one and higher is motivated and presented with examples taken from the recent research literature. Quantitative analysis of the systems is performed using the symbolic manipulator Maple. Prerequisite: Mathematics 32. Offered jointly by CMC and Pomona College. Offered every year.

131. Math Analysis I. *Aksoy*

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. Offered every spring semester.

132. Math Analysis II. *Staff*

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. Offered every other year.

134. Functional Analysis and Its Applications.

Aksoy

This course aims to familiarize students with basic concepts, principles, and methods of functional analysis and its applications. Possible topics include Normed linear spaces and Banach spaces. Continuity and bounded linear operators, Hahn-Banach theorem, and its consequences. The open mapping and closed graph theorems. Differentiation. Geometry of inner product spaces. Hilbert spaces. L^p spaces. Compact operators. Fixed Point Theorem and its application. Prerequisite: Mathematics 60. Offered jointly by CMC, Harvey Mudd College, Pomona College, and Scripps College. Offered every other year.

135. Complex Analysis. *Aksoy, O'Neill*

Introduction to functions of a complex variable. Topics may include: Möbius transformation, multiple-valued functions, Cauchy-Riemann equations, harmonic functions, Cauchy's Theorem, Liouville's Theorem, Cauchy's Integral Formula, Maximum Modulus Principle, Argument Principle, Rouché's Theorem, series expansions, isolated singularities, calculus of residues, conformal mapping. Additional topics at the discretion of the instructor. Prerequisite: Mathematics 60. However, a proof based course above 100 is recommended. Offered jointly by CMC and Pomona College. Offered every year.

137. Real Analysis I. *Staff*

Abstract measures, Lebesgue measure, on \mathbb{R}^n , and Lebesgue-Stieltjes measure on \mathbb{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. Offered every year.

138. Real Analysis II. *Staff*

Continuation of Mathematics 137. Some of the topics covered will be: Banach and Hilbert spaces, L_p spaces, complex measures and Radon-Nikodym theorem. Prerequisite: Mathematics 137. Offered jointly by CMC, Claremont Graduate University, and Pomona College. Offered every year.

139. Fourier Analysis. *O'Neill*

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. Offered every third year.

149. Topics in Mathematics.

In 2008-2009, the topic will be: *Discrete Geometry*.

• *Discrete Geometry. Fukshansky*

The goal of this course is to introduce students to the basics of discrete and convex geometry. Topics covered will include convex bodies, lattices, quadratic forms, and

interactions between them, such as the fundamentals of Minkowski's theory, shortest vector problem, reduction algorithms, LLL, and connections to computational complexity and theoretical computer science. Additional topics may include an introduction to optimization questions, such as tiling, packing, and covering problems. Prerequisites: Mathematics 32 and 60. Offered fall semester.

151. Probability. *O'Neill*

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 60, or permission of instructor. Offered jointly by CMC and Pomona College. Offered every fall semester.

152. Statistical Inference. *O'Neill*

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. Offered every spring semester.

153. Advanced Topics in Statistical Inference. *Staff*

Selected topics in statistical inference including Bayesian Inference, sequential procedures, and distribution free methods. Prerequisite: Mathematics 152. Offered jointly by CMC and Pomona College. Offered every other year.

156. Stochastic Processes and Modeling. *Staff*

Topics chosen from the theory of discrete and continuous Markov chains, second order processes, renewal processes, martingales, Brownian motion, branching processes, random sums, ergodic theory, and stationary processes. Prerequisite: Mathematics 151. Offered jointly by CMC and Pomona College. Offered every other year.

157. Monte Carlo Methods. *O'Neill and Staff*

This course introduces concepts and statistical techniques that are critical to constructing and analyzing effective simulations, and discusses certain applications for simulation and Monte Carlo methods. Topics include random number generation, simulation-based optimization, model building, bias-variance tradeoff, input selection using experimental design, Markov chain Monte-Carlo (MCMC) and numerical integration. Offered occasionally

158. Applied Statistics. *Staff*

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. 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. Offered every other year.

171. Abstract Algebra. *Staff*

The course will introduce the fundamental structures of abstract algebra, including groups, rings, fields, vector spaces, and modules; polynomial and field extensions. Applications to number theory will be presented. Prerequisite: Mathematics 60. Offered jointly by CMC and Pomona College. Offered every fall semester.

173. Advanced Linear Algebra. *Aksoy*

Possible topics include: The spectral theorem for Hermitian matrices and normal operators, Canonical forms, QR factorization and least squares, Singular value decomposition, Calculus of vector and matrix valued functions, Matrix inequalities and positive matrices, Convexity and the duality theorem, Iterative methods for solving systems of linear equations. Prerequisite: Mathematics 60. Offered every other year.

175. Number Theory. *Fukshansky*

Properties of integers, congruences, Diophantine problems, quadratic reciprocity, number theoretic functions, primes. Prerequisite: Mathematics 131, 171, or permission of instructor. Offered jointly by CMC and Pomona College. Offered every other year.

182. Partial Differential Equations. *Staff*

Fourier Series, Fourier Transforms, Distributions. Partial Differential Equations: Heat, Wave, Laplace's, Transport, Schrödinger, Black-Scholes. Reaction-diffusion equations, solitons, and numerical methods. Prerequisites: Mathematics 60 and 111. Offered every year.

186. Stochastic Methods in Operations Research. *Staff*

Simulation Theory, Stochastic models of inventory, reliability, queuing, sequencing, and transportation. Prerequisite: Mathematics 151. Offered jointly by CMC, Claremont Graduate University, Harvey Mudd College, and Pomona College. Offered every other year.

187. Deterministic Methods in Operations Research. *Staff*

Linear, integer, nonlinear, and dynamic programming. Applications to transportation problems, inventory analysis, classical optimization problems, and network analysis, including project planning and control. Prerequisites: Mathematics 32 and 60. Offered jointly by CMC, Claremont Graduate University, Harvey Mudd College, and Pomona College. Offered every other year.

188. Mathematics of Game Theory. *Staff*

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 60; Mathematics 151 recommended. Not open to students who have completed *Economics 129. Game Theory*. Offered every other year.

199. Independent Study in Mathematics or Computer Science. *Staff*

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. Offered every semester.

COMPUTER SCIENCE

51. Introduction to Computer Science. *A. Lee, Pinter-Lucke, Stough*

First computer science course intended for students planning to minor (sequence) or major in computer science or a related field. Students will learn principles of developing object-oriented programs using a modern programming language such as Java. Fundamental concepts covered will include abstraction using classes, control structures, elementary data structures (arrays and linked lists), object-oriented design (using inheritance), elementary algorithms (sorting and searching), recursion, exceptions, debugging, and files. No previous programming experience assumed. Offered every semester.

52. Fundamentals of Computer Science. *A. Lee, Staff*

A solid foundation in functional programming, procedural and data abstraction, recursion, and problem solving. Applications to key areas of computer science, including algorithms and complexity, computer architecture and organization, programming languages, finite automata and computability. Offered jointly by CMC and Pomona College. This course serves the same role as Computer Science 60 at Harvey Mudd College as a prerequisite for upper division computer science courses at any of the Claremont Colleges. Prerequisite: Computer Science 51. Offered every fall semester.

62. Data Structures and Advanced Programming. *A. Lee, Stough*

This course builds on the computing concepts and programming skills acquired in Computer Science 51. Key topics include abstract data types (including stacks, queues, trees, priority queues, dynamic dictionaries, disjoint sets), classical algorithms (including sorting and searching), analysis of algorithms (including worst-case, average-case, and amortized analysis), and storage management. Extensive practice in implementing these data structures in Java. Includes an introduction to manual memory management in C++. This course serves the same role as Computer Science 70 at Harvey Mudd College as a prerequisite for upper division computer science courses at any of the Claremont Colleges. Prerequisite: Computer Science 51. Offered jointly by CMC and Pomona College. Offered every semester.

76. Encryption and Encoding. Staff

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 60; Computer Science 51 recommended. Offered every other year.

81. Computability and Logic. Staff

An introduction to some of the mathematical foundations of computer science, particularly logic, automata, and computability theory. Develops skill in constructing and writing proofs, and demonstrates the applications of the aforementioned areas to problems of practical significance. Prerequisites: Computer Science 62 and Mathematics 50. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every semester.

105. Computer Systems. Staff

Introduction to computer systems from a programmer's point of view. Machine level representations of programs, optimizing program performance, memory hierarchy, linking, exceptional control flow, measuring program performance, virtual memory, concurrent programming with threads, network programming. Prerequisites: Computer Science 62. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every semester.

121. Software Development. Staff

Practical exposure to the process of creating large software systems, including requirements specifications, design, implementation, testing, debugging, and maintenance. Emphasis on software process, software tools (debuggers, profilers, source code repositories, test harnesses), software engineering techniques (time management, code and documentation standards, source code management, object-oriented analysis and design), development methods (pair programming, test first development, etc.), and team development practice. Some of the work will be in groups. Prerequisite: Computer Science 62. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every spring semester.

131. Programming Languages. Staff

Ideas behind the design and implementation of programming languages. Syntactic description, scope and lifetime of variables, runtime stack organization,

parsing and abstract syntax, semantic issues, type systems, programming paradigms, interpreters and compilers. Prerequisites: Computer Science 81 or permission of the instructor. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every semester.

133. Database Systems. A. Lee

Representing information about real world enterprises using important data models including the entity-relationship, relational and object-oriented approaches. Database design criteria, including normalization and integrity constraints. Implementation techniques using commercial database management system software. Selected advanced topics such as distributed, temporal, active, and multi-media databases. Prerequisite: Computer Science 81 or permission of the instructor. Offered every spring semester.

134. Operating Systems. Staff

Characteristics, objectives, and issues concerning computer operating systems. Hardware/software interactions, process management, memory management, protection, synchronization, resource allocation, file systems, security, and distributed systems. Extensive systems programming. Prerequisite: Computer Science 105. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every semester.

135. Distributed Software Architecture. A. Lee

Software architectures, programming models, and programming environments pertinent to developing Internet applications. Topics include network protocols, client-server model, multi-tier software architecture, client-side scripting (e.g., JavaScript), server-side programming (e.g., Servlets and JavaServer Pages), component reuse (e.g., JavaBeans), database connectivity (e.g., JDBC), web servers, and developing web applications. Requires team project. Prerequisite: Computer Science 62. Offered every fall semester.

140. Algorithms. Staff

Balanced trees, string matching, graph algorithms, external sorting and searching. Dynamic programming, exhaustive search. Space and time complexity, derivation and solution of recurrence relations, complexity hierarchies, reducibility, NP completeness. Prerequisites: Computer Science 62 and Mathematics 50. Offered jointly by CMC, Harvey Mudd College, and Pomona College. Offered every semester.

181. Special Topics in Computer Science. Staff

Selected topics in computer science. May be repeated for credit. Permission of instructor required. During the **2009 Spring semester**, the topic will be **Image Analysis**; the course will be taught by *Professor Stough*.