
Mathematics and Computer Science

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The primary goal of the programs in mathematics and computer science at Holy Cross is to enable students to become active participants in the study of fundamental and dynamic areas of human endeavor. The inherent structure and beauty of mathematics is at the core of all mathematical inquiry. Mathematics is also the language of the sciences and social sciences, and in our increasingly technology-driven society, it is part of our daily public discourse. Computing has become an indispensable tool for scientific and mathematical experimentation. The academic discipline of computer science studies algorithms, data structures, and their realization in software and hardware systems. It addresses the fundamental questions: What is computable in principle? And what tasks are algorithmically feasible? Thus the programs in mathematics and computer science are both informed by other disciplines and seek out ways that mathematics and computing have an impact on the world at large. In this context the department works toward helping students to become knowledgeable and sophisticated learners, able to think and work independently and in concert with their peers.

The department offers a number of introductory courses, a major in mathematics, a major in computer science and a minor in computer science open to students majoring in any department, including mathematics. Computing courses do not count toward the maximum number of courses which may be taken in one department for mathematics majors, nor do mathematics courses count toward the maximum number of courses which may be taken in one department for computer science majors.

Advanced Placement and Introductory Courses

Students who have received a score of 4 or 5 on the AP Calculus AB exam will earn one unit of credit, and are advised to take Mathematics 136, Mathematics 126, or Mathematics 132. Students will forfeit their AP credit if they opt to take Mathematics 125, 131, or 133. Students who have successfully completed a year of calculus in high school, but who did not take the AP exam, or who scored a 3 or lower on the AP Calculus AB exam should still consider starting with Mathematics 136 (AP Calculus), since much of the material in Mathematics 125, Mathematics 131, or Mathematics 133 will be review. Successful completion of Mathematics 136 fulfills any college requirement for a full year of calculus.

Students who receive a score of 4 or 5 on the AP Calculus BC exam and an AB subscore of 4 or 5 will earn two units of credit and are advised to take Mathematics 241 (Multivariable Calculus). One AP credit will be lost if the student starts in Mathematics 126, 132, 134, or 136, and both credits will be lost if the student starts in Mathematics 125, 131, or 133. Students who receive a score of 3 or lower

on the BC exam and an AB subscore of 4 or 5 will earn one unit of credit and are advised to take Mathematics 136, Mathematics 126, or Mathematics 132. Students will forfeit their AP credit if they opt to take Mathematics 125, 131, or 133.

The sequences Mathematics 125, 126 and Mathematics 131, 132 (or 133, 134) are alternatives to each other. No student may earn credit for any two of Mathematics 125, 131, and 133. Mathematics 125, 126 is normally a terminal sequence. Students considering taking additional mathematics courses beyond first year calculus should begin in Mathematics 131, 136 or 241.

Students who have received a score of 4 on the AP Computer Science AB exam or a score of 4 or 5 on the AP Computer Science A exam will earn one unit of credit (for Computer Science 131, Techniques of Programming), and are advised to take Computer Science 132 (Data Structures). Students will forfeit their AP credit if they opt to take Computer Science 131 or 110. Students who have received a score of 5 on the AP Computer Science AB exam will earn one unit of credit and are advised to take Computer Science 226 (Computer Systems and Organization). Students will forfeit their AP credit if they opt to take Computer Science 131 or 110.

The Major in Mathematics

At least 10 semester courses in mathematics are required for the major. The foundation consists of required courses in calculus and algebra: Mathematics 131, 132 (or equivalents), 241, 242, 243, and 244. Mathematics majors begin their studies in the three-semester Mathematics 131, 132, 241 calculus sequence. Majors who enter with advanced placement credit in calculus or who have taken a year-long calculus course in high school may begin in Mathematics 136 or Mathematics 241 as appropriate. Advanced placement credits may be used to count toward the 10 required courses for the major. Students who need a more intensive first course may also begin in Mathematics 133, 134. The calculus sequence is followed by the one-semester course Principles of Analysis (Mathematics 242), which studies the theoretical foundations of the calculus. In addition, in their second year, mathematics majors normally take the two-semester sequence Algebraic Structures and Linear Algebra (Mathematics 243, 244).

Beyond the basic courses discussed above, majors are required to take at least four courses numbered above 300. These courses are electives, subject to the guiding principles that each major's course selections should include both a broad range of courses within mathematics and a study of at least one area in depth. To demonstrate breadth, mathematics majors must complete at least one semester course in three of the following four areas: Analysis, Algebra, Geometry and Topology, and Applied Mathematics. The course listings that follow show which regular upper-level mathematics courses fall within each of the four breadth areas, and all majors will consult with their academic advisers no later than the end of their second year to plan their major course selections with this requirement in mind. The four upper-level courses must also include a full-year linked sequence in some subject to provide depth. The regularly offered full-year linked sequences are indicated in the course listings.

Majors are encouraged to take advantage of the close student-faculty contact afforded by upper-division seminars, independent study projects, and departmental honors, which permit students to explore topics of mutual interest to students and faculty that are not part of the regular course offerings. Also, throughout the curriculum, in courses and in independent work, students are able to explore and utilize the growing relationship between mathematics and computing.

The Major in Computer Science

Computer Science Majors must complete a minimum of 10 one-semester courses in computer science. These include seven required core courses and at least three additional upper-level (numbered 300 or above) electives. In addition, all majors must complete the equivalent of one semester of calculus. Prospective computer science majors are strongly encouraged to complete the equivalent of two semesters of calculus. Advanced placement credit may be used to count toward the 10 required courses for the major.

The required computer science core consists of three introductory, two intermediate and two upper-level courses. The introductory core courses are the two semester Computer Science 131-132 (Tech-

niques of Programming and Data Structures) sequence and Computer Science 135 (Discrete Structures), a course dealing with the discrete mathematical foundations of the subject. Mathematics 243 (Algebraic Structures) may be substituted for Discrete Structures. The intermediate core courses are Computer Science 226 (Computer Systems and Organization) and Computer Science 235 (Analysis of Algorithms), and the upper-level core courses are Computer Science 324 (Programming Languages Design and Implementation) and Computer Science 328 (Ethical Issues in Computer Science).

In addition to the core courses, majors are required to take at least three elective courses numbered above 300. We strongly recommend that students take at least one upper-level course carrying the project course designation. A project course allows students to combine skills and concepts they have previously learned during their undergraduate courses with new material in a complex implementation task. The project course is often scheduled for the last year of undergraduate study, where it can serve as a capstone for the undergraduate experience.

The Minor in Computer Science

The requirements for the computer science minor include seven courses in total: Two dealing with mathematical foundations and five in computer science. Advanced placement credit may be used to count toward the required courses for the minor.

The mathematics requirements are one course in calculus and Computer Science 135 (Discrete Structures), a course dealing with the discrete mathematical foundations of the subject. Mathematics 243 (Algebraic Structures) may be substituted for Discrete Structures. To fulfill the calculus requirement, prospective computer science minors may take either Mathematics 125, 131, 133, 136, or use AP credit. Prospective computer science minors satisfying this requirement with Mathematics 125, 131, or 133 are strongly encouraged to continue with the second semester course Mathematics 126, 132, or 134 as appropriate.

The required computer science courses are Computer Science 131, 132 (Techniques of Programming and Data Structures) sequence, Computer Science 226 (Computer Systems and Organization), plus either two additional 300-level courses or 235 (Analysis of Algorithms) and an additional 300-level course.

Other Information

Facilities available for study and research are excellent. The O'Callahan Science Library in the Swords Science Center and the College's extensive major computing facilities are described elsewhere in the Catalog. In addition, computer science and mathematics students will have the opportunity to use the Department's PC laboratory in the lower-division courses and Linux network in upper-division courses.

Students who are interested in teaching mathematics at the secondary school level and wish to undertake the College program leading to licensure, should consult with the Department Chair and with the Director of the Teacher Education Program early in the sophomore year. Students who are interested in majoring in mathematics and participating in the 3-2 Program in Engineering should consult with the director of that program and the Chair of the Department.

Mathematics Honors Program

The program has two levels of distinction, Honors and High Honors. Each requires that the student develop a solid foundation in the core areas of real analysis and algebra and that the student build on this foundation by taking a full complement of courses within the department. High Honors is distinguished from Honors by the successful completion of a fourth-year honors thesis. Any questions concerning the program should be directed to the Departmental Honors Program Director or the Department Chair.

Course Requirements for Honors. All regular course requirements for the mathematics major. In addition, for Honors, students must take at least seven courses numbered above 300. These seven must

include at least two seminar courses, at least two linked sequences, and three semester-long courses distributed between the Algebra and Analysis breadth areas.

Course Requirements for High Honors. All regular course requirements for the mathematics major. In addition, for High Honors, students must take six courses numbered above 300, and complete a fourth-year honors thesis. The six regular courses must include at least two semester courses in the Algebra breadth area, and two semester courses in the Analysis breadth area. Three of the six courses must be seminars.

Note: Exceptions to some of the course requirements for either Honors or High Honors may be possible, for example, for students who participate in the Study Abroad Program. Students considering Honors should consult with the Departmental Honors Program director before leaving for Study Abroad concerning any modifications of these requirements.

GPA Requirements for Honors and High Honors. The average GPA for mathematics courses above the level of Mathematics 136 (or mathematics courses above the level of 136 and computer science courses, for mathematics majors minoring in computer science) must be at least 3.40 at the end of the fall semester of the fourth year.

Fourth-Year Honors Presentation. During the fourth year all Honors majors must give an oral presentation open to the department and majors on an important problem or result. This may be related to their coursework but it is not intended to duplicate material normally in the curriculum. Neither is this intended to be a large-scale project. The goal is to ensure a certain degree of mathematical literacy among the Honors majors.

Fourth-Year Honors Thesis for High Honors. This is a large project extending over the course of the fourth year. The thesis can either consist of original research or be of an expository nature and is written under the guidance of one or more members of the department. This project should entail a significant amount of problem solving. It will culminate in an oral presentation during the spring term of the fourth year, which will be accompanied by a written report of the year's work. Normally, a student will earn one unit in the spring semester of the fourth year for successful completion of an honors thesis unless the thesis work is done as part of the student's participation in a departmental seminar. In the latter case, no extra credit will be given above the credit for the seminar itself. For a particularly extensive project, and with the permission of the Department Chair, a student may earn one unit in each semester of the fourth year for completion of the thesis.

Computer Science Honors Program

Course Requirements for High Honors. Students must complete all regular course requirements for the computer science major. In addition, for High Honors, students must take six courses numbered above 300 and complete a fourth year honors thesis. This is a large project extending over the course of the fourth year. The thesis can either consist of original research or be of an expository nature and is written under the guidance of one or more members of the department.

GPA Requirement for High Honors. The average GPA for courses in Computer Science must be at least 3.50 at the end of the fall semester of the fourth year.

Courses

Mathematics Courses

Mathematics 110 — Topics in Mathematics

Fall, spring

Consideration of diverse subjects in mathematics. Content varies from semester to semester with specific subject matter for each course announced just prior to enrollment. Designed for non-majors who wish to study mathematics other than calculus. One unit.

Mathematics 125, 126 — Calculus for the Social Sciences 1, 2*Annually*

A two-semester introduction to the calculus of one variable primarily intended for students majoring in economics. Topics discussed include differentiation and integration of real valued functions of one real variable, techniques of integration and differentiation, max-min problems and improper integrals, series, and differential equations. Applications to economics and the social sciences are emphasized. This is a terminal sequence; students planning to take more than two semesters of mathematics should enroll in Mathematics 131, 132. One unit each semester.

Mathematics 131, 132 — Calculus for the Physical and Life Sciences 1, 2*Annually*

Considers the calculus of real-valued functions of one variable for students who are planning further coursework in mathematics or a major in the sciences. Emphasis is placed on a conceptual understanding of the calculus, presenting material from symbolic, numerical, and graphical points of view. The course makes regular use of calculators or computers and considers a variety of applications to the sciences and social sciences. In the first semester, the concepts of limit, continuity, derivative and integral are developed and applied to algebraic, logarithmic, exponential and trigonometric functions. The second term focuses on the theory and applications of integration, Taylor polynomials and Taylor series, and ordinary differential equations. This course is the prerequisite for Mathematics 241, 242. This course meets four hours per week. One and one-quarter units each semester.

Mathematics 133, 134 — Intensive Calculus for the Physical and Life Sciences 1, 2*Annually*

This sequence is an intensive version of Mathematics 131, 132 that is designed for students with an interest in pursuing a major in mathematics or the sciences, or the premedical program, who require more class time to make the transition to college-level mathematics. See the description of Mathematics 131, 132 for the course content. This course meets five hours per week. One and one-quarter units each semester.

Mathematics 136 — Advanced Placement Calculus*Fall*

This course is a one-semester version of Mathematics 131, 132 for those students who have either received one unit of advanced placement credit in calculus or who have taken a year of calculus in high school. See the description of Mathematics 131, 132 for the course content. This course meets four hours per week. One and one-quarter units.

Mathematics 241 — Multivariable Calculus*Fall, spring*

A study of the calculus of functions of several variables. Concerns the theory and applications of differentiation and integration of functions of several variables, vector fields, line integrals, Green's theorem. Prerequisite: Mathematics 132, 134, 136 or the equivalent. This course meets four hours per week. One and one-quarter units.

Mathematics 242 — Principles of Analysis*Fall, spring*

An in-depth study of the theory of the calculus of functions of one variable. Topics include sequences, series, continuity, differentiability, the extreme value theorem, the mean value theorem, Riemann integration, and the fundamental theorem of calculus. Prerequisite: Mathematics 241. One unit.

Mathematics 243 — Algebraic Structures*Fall*

An introduction to the primary structures in abstract algebra—groups, rings and fields—and the corresponding concept of homomorphism for each of these structures. Emphasis placed on using the language of sets, relations, equivalence relations and functions, and developing techniques of proof, including elementary logic and mathematical induction. Prerequisite: Mathematics 132, 134, 136 or equivalent. One unit.

Mathematics 244 — Linear Algebra*Spring*

Designed to acquaint students with the basic techniques of linear algebra. Topics include matrices, vector spaces, subspaces, linear transformations, bilinear forms, determinants, eigenvalue theory, and the finite dimensional spectral theorem. Applications and additional topics are included as time permits. Prerequisite: Mathematics 243. One unit.

Mathematics 301 — Topics in Geometry*Alternate years*

Centers on some area of geometry other than differential geometry. Possible topics include Euclidean and

non-Euclidean geometry, projective geometry, the geometry of transformation groups, and the elementary geometry of algebraic curves. Prerequisite: Mathematics 241 and 244. Breadth area: Geometry and Topology. One unit.

Mathematics 302 — Differential Geometry

Alternate years

A first course in the differential geometry of curves and surfaces for students who have completed Mathematics 241 and a semester course in linear algebra. Topics include the Frenet-Serret formulas, smooth surfaces in 3-space, fundamental forms, differentiable manifolds, vector fields, connections and a brief introduction to Riemannian geometry. Prerequisite: Mathematics 241 and 244. Breadth area: Geometry and Topology. One unit.

Mathematics 303 — Mathematical Models

Alternate years

Introduction to the role of mathematics as a modeling tool, including the construction, interpretation and application of mathematical models. Applications chosen to illustrate various modeling paradigms such as deterministic, probabilistic, discrete and continuous modeling and may include population dynamics, biomedical applications, stock market analysis, and network and traffic flows. Prerequisite: Mathematics 242 and 244. Breadth area: Applied Mathematics. One unit.

Mathematics 304 — Ordinary Differential Equations

Alternate years, fall

Linear differential equations are studied; basic existence theorems are proved; equations with constant coefficients and series methods are treated in detail. Topics in non-linear systems are discussed, including existence and uniqueness theorems and series methods. Prerequisite: Mathematics 242 and 244. Mathematics 304 – 373 is a full-year linked sequence. Breadth area: Applied Mathematics. One unit.

Mathematics 305 — Complex Analysis

Alternate years

The fundamentals of complex analysis. Topics include the complex number system, analytic functions, the Cauchy-Riemann equations, Cauchy's integral theorem, Cauchy's integral formula, Taylor series, Laurent series, the calculus of residues and conformal mapping. Prerequisite: Mathematics 242. Breadth area: Analysis. One unit.

Mathematics 351, 352 — Abstract Algebra

Alternate years

An in-depth study of the structure of groups, rings and fields. Depending on the instructor, applications to Galois theory, number theory, geometry, topology, physics, etc., are presented. Prerequisite: Mathematics 244. Mathematics 351 – 352 is a full-year linked sequence. Breadth area: Algebra. One unit each semester.

Mathematics 357 — Combinatorics

Alternate years

A breadth-first introduction to the subject that discusses a representative sampling of combinatorial problems and general techniques for solving them, including a selection of counting techniques, techniques for existence questions, and a variety of examples. Examples may include partitions, graphs and trees, graph traversals, tournaments, graph coloring and chromatic polynomials, magic squares, Latin rectangles and squares, and combinatorial block designs. Prerequisite: Mathematics 244. Breadth area: Algebra. One unit.

Mathematics 361, 362 — Real and Abstract Analysis

Alternate years

Topological ideas are introduced through a treatment of metric space topology. After the study of open, closed, compact and connected spaces with emphasis on their behavior under continuous mappings, selected topics from functional analysis are considered. These include \limsup and \liminf , relation of uniform convergence to differentiation and integration, and the Stone Weierstrass approximation theorem. The second semester topics include an introduction to Lebesgue-Stieltjes integration, Hilbert space and other material from linear space theory. Prerequisite: Mathematics 242 and 244. Mathematics 361 – 362 is a full-year linked sequence. Breadth area: Analysis. One unit each semester.

Mathematics 363 — Topics in Topology

Alternate years

Considers various aspects of topology of surfaces and solids, including orientability, the Euler number, and the fundamental group. One of the goals of the course is the topological classification of surfaces. Prerequisite: Mathematics 242 and 244. Breadth area: Geometry and Topology. One unit.

Mathematics 371 — Methods of Numerical Analysis

Alternate years

The numerical solution of problems using computers. Considerable time is devoted to selecting the appropriate algorithm for a given problem and analyzing the resulting numerical errors. Includes such topics as error analysis of computer arithmetic, approximation of functions, solution of equations, numerical integration, numerical solution of ordinary differential equations. Prerequisite: Mathematics 242 and 244. Breadth

area: Analysis. One unit.

Mathematics 372 — Numerical Linear Algebra

Alternate years

The numerical solution of problems from linear algebra using computers. Gaussian elimination in floating point arithmetic, iterative techniques for solving systems of linear equations, numerical eigenvalue and diagonalization methods. Applications. Prerequisite: Mathematics 242 and 244. Breadth area: Applied Mathematics. One unit.

Mathematics 373 — Principles and Techniques of Applied Mathematics

Alternate years, spring

Provides an understanding of a wide spectrum of phenomena through the use of mathematical ideas, abstractions, and techniques. Topics included are partial differential equations, including the heat and wave equations, Fourier analysis, eigenvalue problems, Green's functions. This course is now offered in a full-year linked sequence beginning with Mathematics 304 (Ordinary Differential Equations). Prerequisite: Mathematics 304. Breadth area: Applied Mathematics. One unit.

Mathematics 374 — Dynamical Systems

Alternate years

An introduction to the theory of discrete dynamical systems. Topics include iteration of functions, graphical analysis, periodic points, stable sets, chaos, symbolic dynamics, the dynamics of functions of a complex variable and the Mandelbrot set. The major theorems will be studied along with their proofs and the computer will be used as a research tool to do experiments which motivate and illustrate the theory. Prerequisite: Mathematics 242 and Mathematics 244. Breadth Area: Applied Mathematics. One unit.

Mathematics 375, 376 — Probability and Statistics

Alternate years

Provides an introduction to the theory and applications of probability and statistics. Topics in probability theory include both continuous and discrete distributions, conditional probability, random variables, expectation, and the Central Limit Theorem. Topics in statistics include maximum likelihood estimation, the sampling distributions of estimators, hypothesis testing, regression analysis, and an introduction to the analysis of variance. Prerequisite: Mathematics 242 and Mathematics 244. Mathematics 375 – 376 is a full-year linked sequence. Breadth area: Applied Mathematics. One unit each semester.

Mathematics 392 — Seminar

Annually

Provides an opportunity for individual and group investigation of topics not covered in ordinary course work. Active participation on the part of the students is normally required. Subject matter varies to suit individual students and is often related to the research activity of the professor. Examples of areas of study: Lie groups, functional analysis, complex analysis, probability theory, commutative algebra, applied mathematics, the classical groups, mathematical logic, automata and formal languages, topics in discrete modeling, and qualitative theory of differential equations. A breadth area designation will be made individually for each seminar course by the department chair, in consultation with the faculty member teaching the seminar. Breadth area depends on the subject matter. One unit each semester.

Mathematics 400 — Directed Reading

Fall, spring

An independent reading project for upper division students. Normally this is on a topic that is not covered by the regular course offerings. Permission of the instructor and the department chair is required for this course. One unit.

Mathematics 495, 496 — Mathematics Honors Thesis

Annually

A large project extending over the course of the fourth year. It can consist of original research or be of an expository nature and is written under the guidance of one or more members of the department. Normally, a student will earn one unit in the spring semester of the fourth year for successful completion of an honors thesis, unless the thesis work is done as part of the student's participation in a departmental seminar. In that case, no extra credit is given above the credit for the seminar itself. For a particularly extensive project, and with the permission of the department chair, a student may earn one unit in each semester of the fourth year for completion of the thesis.

Computer Science Courses

Computer Science 110 — Survey of Computer Science

Fall, spring

A survey of the science and art of computing intended for students not majoring in mathematics or science. Half of the course is an introduction to computer programming. Emphasis is placed upon language-independent topics such as structured programming, good programming style, the use of subprograms, and algorithm construction in general. The other half of the course explores how computers are built, how they operate, and what their fundamental limitations are. A portion of the course will be devoted to technical and

ethical risks, problems, and disasters. One unit.

Computer Science 131 — Techniques of Programming

Fall

An intensive introduction to object-oriented programming in a high-level language for students considering further course work in computing or students majoring in mathematics, the sciences, economics or any other field in which computer programming plays a role. It is expected that most of the class will continue with Computer Science 132, Data Structures. There is a required weekly lab meeting of this course. One and one-quarter units.

Computer Science 132 — Data Structures

Spring

Introduction to standard data structures such as stacks, lists, trees, and graphs. Algorithms and techniques for sorting, searching, graph traversal, hashing, and recursion are discussed. Analysis of algorithms and special topics are covered as time allows. There is a required weekly lab meeting of this course. Prerequisite: Computer Science 131, or equivalent. One and one quarter units.

Computer Science 135 — Discrete Structures

Spring

Introduction to the discrete mathematical structures that form the basis of computer science. Topics include proof techniques, relations and functions, set theory, Boolean algebra and propositional logic, predicate calculus, graphs, trees, induction and recursion, counting techniques and discrete probability. It is recommended this class be taken concurrently with Computer Science 132. One unit.

Computer Science 226 — Computer Systems and Organization

Fall

Covers fundamental topics related to the design and operation of a modern computing system. Relationships are drawn between circuits and system software. Topics include hardware and software organization, virtual machines, physical fundamentals of transistors, digital logic design, memory system organization, architecture and management, CPU design, multiprocessors, data representation, machine language, micro-programming, assembly language, assemblers and linkers, CISC versus RISC, interrupts and asynchronous event handling, networking, and the past and present of computer system design, architecture, and organization. Prerequisite: Computer Science 132. One unit.

Computer Science 235 — Analysis of Algorithms

Alternate years in fall

Provides an introduction to the design and analysis of fundamental algorithms and their complexity. Presents several algorithm design strategies that build on the data structures and programming techniques introduced in Computer Science 132. The general techniques covered include: Divide-and-conquer algorithms, dynamic programming, greediness and probabilistic algorithms. Topics include: sorting, searching, graph algorithms, O -notation, and introduction to the classes P and NP, and NP-completeness. Prerequisite: Computer Science 132 and Calculus or permission of instructor. One unit.

Computer Science 324 — Programming Languages Design and Implementation

Spring

Principles for designing and implementing programming languages are presented as well as styles and features that encourage and discourage the writing of good software. Topics include language syntax and semantics, comparison of language features and their implementation, methods of processing a program, establishing the run-time environment of the program and the major programming language paradigms (the imperative/procedural, functional/applicative, declarative/logic and object-oriented paradigms). Prerequisite: Computer Science 226. One unit.

Computer Science 328 — Ethical Issues in Computer Science

Alternate years in fall

Examines the ethical issues that arise as a result of increasing use of computers, and the responsibilities of those who work with computers, either as computer science professionals or end users. The course stresses the ways in which computers challenge traditional ethical and philosophical concepts, and raise old issues in a new way. Students expected to read and understand the ideas in the readings, explain the ideas, analyze issues and see them from diverse perspectives, and formulate and critique arguments. Readings include technical issues in computer science and may focus on a particular area such as software design as well as more traditional topics such as philosophical theories (e.g. ethical relativism, utilitarianism, deontological theories, rights and virtue ethics), privacy, intellectual property rights and proprietary software, security, accountability, liability, the digital divide, hacking, and viruses.

There are several course goals: (1) to give a fuller, richer, deeper understanding of the social impact of computers and the ethical issues in human activities affected by computers, (2) to prepare the student for living in a computerized world and perhaps working as a professional in the computing field, and (3) to improve presentation, debating and writing skills. Prerequisite: Computer Science 132. One unit.

Computer Science 343 — Computer Graphics*Alternate years*

A survey of topics in computer graphics with an emphasis on fundamental techniques and the theory underlying those techniques. Topics include the fundamentals of two and three dimensional graphics such as clipping, windowing, and coordinate transformations (e.g., positioning of objects and camera), raster graphics techniques such as line drawing and filling algorithms, hidden surface removal, shading, color, curves and surfaces and animation. Students learn how to program graphics displays using a state-of-the-art computer graphics package. Prerequisite: Computer Science 132 and Calculus or permission of instructor. One unit.

Computer Science 345 — Theory of Computation*Alternate years*

Basic aspects of regular, context-free, context sensitive and unrestricted grammars, propositional and predicate calculus, recursive functions, automata theory and computational complexity. Prerequisite: Computer Science 132. One unit.

Computer Science 346 — Operating Systems*Alternate years*

An introduction to the design and implementation of computer operating systems. Students learn techniques for managing hardware resources and sharing them among many competing processes and threads. Studies the internal structures needed for process and thread management, synchronization, inter-process communication, memory management (including shared memory), file system management, device control, and security. Prerequisite: CSCI 226. One unit.

Computer Science 363 — Computational Vision*Alternate years*

An introduction to the algorithms underlying machine and biological visual systems. Examines the processes involved in converting a 2-dimensional image to a 3-D representation of the physical world. Computational models of visual processing will be compared to physiological and psychophysical results from human and other biological visual systems. Topics covered include: edge detection, stereopsis, motion computation, shape from shading, color and object recognition. Prerequisite: Computer Science 132 and Calculus, or permission of the instructor. One unit.

Computer Science 364 — Compiler Construction*Alternate years*

The theories, tools and techniques for translator creation are the focus of this course. Topics include: regular expressions, grammars, finite state machines, lexical analysis, parsing, linguistic approaches to problem solving, intermediate code trees, register allocation, code generation, a variety of optimization schemes and techniques as well as Linux-style support for translation such as lex and yacc. An essential and distinguishing feature of the course is the project requirement. Students are required to build a working compiler that is a large software engineering project of significant complexity. This course carries the project course designation. Prerequisite: Computer Science 324 or permission of the instructor. One unit.

Computer Science 399 — Topics in Computer Science*Alternate years*

This course gives the student a chance to see the principles introduced in earlier courses applied in specific areas and gives faculty an opportunity to teach material of special interest to them. The most likely topics are artificial intelligence, database systems, advanced theory of computation, and robotics. Prerequisite: varies by topic. One unit.

Computer Science 400 — Directed Reading*Fall, spring*

An independent reading project for upper division students. Normally this will be on a topic that is not covered by the regular course offerings. Permission of the instructor and the Department Chair is required for this course. One unit.

Computer Science 495, 496— Computer Science Honors Thesis*Annually*

This is a large project extending over the course of the fourth year. It can consist of original research or be of an expository nature and is written under the guidance of one or more members of the department. A student will earn at least one unit of credit in the spring semester of the fourth year for successful completion of an honors thesis, unless the thesis work is done as part of the student's participation in a department seminar. In that case, no extra credit is given above the credit for the seminar itself. For a particularly extensive project, and with the permission of the department chair, a student may earn one unit in each semester of the fourth year for the completion of the thesis. One unit.