science will have acquired the ability to:

Students who complete the Bachelor of Science in Computer Science elective units.

However, ENGR 181, ENGR 183, ENGR 184, or ENGR 185 may be applied towards the 120 units required to earn the Bachelor of Science in Computer Science. Up to four units of COMP 187, ENGR 181, or ENGR 182 may be used as computer science elective units.

Students who complete the Bachelor of Science in Computer Science will have acquired the ability to:

1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
2. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
3. Communicate effectively in a variety of professional contexts.
4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

Bachelor of Science in Computer Science

Students must complete a minimum of 120 units with a Pacific cumulative and major/program grade point average of 2.0 in order to earn the Bachelor of Science in Computer Science.

I. General Education Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS 001</td>
<td>What is a Good Society</td>
<td>4</td>
</tr>
<tr>
<td>PACS 002</td>
<td>Topical Seminar on a Good Society</td>
<td>4</td>
</tr>
<tr>
<td>PACS 003</td>
<td>What is an Ethical Life?</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: 1) Pacific Seminars cannot be taken for Pass/No Credit. 2) Only one course can come from each subcategory (A, B, or C) within each category. 3) No more than 2 courses from a single department may be applied to meet the breadth program requirements, with the exception of certain 1-unit GE IIC courses.

II. Diversity Requirement

Students must complete one diversity course (3-4 units)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 030</td>
<td>Engineering and Computing Ethics in Society</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: 1) Transfer students with 28 units or more transfer units prior to fall 2011 are encouraged but not required to complete a designated diversity course prior to graduation. 2) Diversity course may also be used to meet general education and/or major/minor requirements.
III. Fundamental Skills

Students must demonstrate competence in:

| Writing
| Quantitative analysis

**Note:** 1) Fundamental skills must be satisfied prior to enrolling in upper division courses.

IV. Major Requirements

**Mathematics and Science**

15 units in mathematics and 8 units in laboratory science. COMP 047, COMP 147 and ECPE 127 count as mathematics units.

| COMP 147 | Computing Theory | 4 |
| COMP 047 | Discrete Math for Computer Science | 4 |
| MATH 074 | Discrete and Combinatorial Mathematics | 3-4 |
| ECPE 127 | Random Signals | 4 |
| MATH 037 | Introduction to Statistics and Probability | 4 |
| MATH 039 | Probability with Applications to Statistics | 4 |
| MATH 045 | Introduction to Finite Mathematics and Calculus | 4 |
| MATH 051 | Calculus I | 4 |

Select one of the following: Two laboratory science courses which can be any General Education Category IIIA course.

| MATH 052 | Calculus II | 4 |
| MATH 053 | Calculus III | 4 |
| MATH 054 | Advanced Calculus | 4 |
| MATH 055 | Linear Algebra | 4 |

V. Computer Science Electives and Areas of Concentration

17 units

Students complete their degree with 17 additional units of upper division computer science courses, beyond the core courses, which students select in consultation with their academic advisor. Areas of concentration may be selected by students to allow them to specialize in an area appropriate for their post-graduation plans. If students elect to pursue an area of concentration then they must complete the four courses required for that concentration, plus three additional units selected in consultation with their academic advisor. Up to four units of ENGR 182, or COMP 187 may be substituted for one upper division computer science elective.

**Networking and Computer Security Concentration**

Career options: Systems administrator, security specialist, network administrator, network appliance developer

| COMP 127 | Web Applications | 4 |
| COMP 175 | System Administration and Security | 3 |
| COMP 177 | Computer Networking | 4 |
| COMP 178 | Computer Network Security | 3 |
| Electives selected with advisor | 3 |

**Software Development Concentration**

Career options: Application developer, software engineer, software architect, quality assurance

| COMP 129 | Software Engineering | 4 |
| COMP 135 | Human-Computer Interface Design | 3 |
| COMP 137 | Parallel Computing | 3 |
| COMP 163 | Database Management Systems | 4 |
| Electives selected with advisor | 3 |

**Graphics and Simulation Concentration**

Career options: Game engine developer, simulation developer, training system developer, scientific application developer, games/animation tools developer, graphics/multimedia application developer

| COMP 151 | Artificial Intelligence | 3 |
| COMP 153 | Computer Graphics | 3 |
| COMP 155 | Computer Simulation | 4 |
| COMP 159 | Computer Game Technologies | 4 |
| Electives selected with advisor | 3 |

**Computer Science Courses**

- **COMP 025. Computers and Information Processing. 4 Units.**
  This introductory information technology course focuses on computer architecture, networking, internet technologies and the integration of productivity software. Lectures, readings, hands-on projects and lab assignments give a variety of learning experiences. Specific topics include computer architecture, digital data, networking, file management, spreadsheets, database systems and presentation applications. Students are exposed to JavaScript and Visual Basic scripting. Particular emphasis is placed on HTML programming and creating an interactive student website for homework and lab linking throughout the semester. Prerequisite: Fundamental Math Skills requirement. (GE3B)

- **COMP 041. Great Ideas in Computing. 4 Units.**
  This course is a broad introduction to the field of computing. The concepts that are the foundation of computing are presented and placed in historical context. Discussion topics include the ways of thinking and working that make computing effective, and the future of the field. Example topics include number representation, architecture of computing systems, intelligent computing systems, and the use of computing in art and games. Prerequisite: Fundamental Math Skills requirement. (GE3C)

- **COMP 047. Discrete Math for Computer Science. 4 Units.**
  This course is designed to develop skills in deductive reasoning and to apply concepts of discrete mathematics to computer science. Topics include logic, deductive reasoning, mathematical induction, set theory, functions, recurrence relations, combinatorics and probability, graphs, trees, and Boolean Algebra. Prerequisite: Fundamental Math Skills requirement. (Spring, every year). (GE3B)
COMP 051. Introduction to Computer Science. 4 Units.
The course emphasizes program design and problem solving techniques that use a high-level programming language. The course introduces basic concepts such as assignment, control flow, iteration, and basic data structures in addition to a supervised lab. Credit for this course is not given if a student has credit for COMP 061. Prerequisite: Fundamental Math Skills requirement. (GE3B)

COMP 053. Data Structures. 4 Units.
The course continues the development of program design and problem solving techniques. Topics include development of fundamental data structures and their associated algorithms as well as array-based algorithms, recursion, lists, generics, dynamic memory, binary trees, and associative structures. Prerequisite: COMP 051 or COMP 061 with a "C-" or better.

COMP 055. Application Development. 4 Units.
This course develops the skills and techniques required for the creation of contemporary software applications. Contemporary software applications are complex systems that involve the interaction of multiple subsystems that require teams of developers working together for extended periods of time. Topics include team work and communication skills, current development methodologies, analysis and design documentation and the use of libraries. This course is intended to prepare students to transition to upper division courses. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. (Fall, every year).

COMP 061. Introduction to Programming for Data Science. 4 Units.
This course introduces programming concepts and program design using topics in data science as examples. Basic concepts such as assignment, control flow, iteration, and simple as well as object-oriented data types and structures are developed. The course includes a supervised lab. Credit for this course is not given if student has credit for COMP 051. Prerequisite: Fundamental Math Skills requirement. (GE3B)

COMP 093. Special Topics. 3 or 4 Units.

COMP 127. Web Applications. 4 Units.
The World-Wide Web consists of client-server applications operating over the Internet. This course introduces the skills and techniques for designing and developing web applications. Topics include: client-server architectures, web servers and web browsers, server-side programming, client-side programming, form processing, state management and multimedia. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better or permission of instructor. (Fall, even years).

COMP 129. Software Engineering. 4 Units.
Students gain practical experience in dealing with medium to large scale software systems. Students learn how current analysis and design methodologies are used to develop the abstractions necessary to understand large systems. Students also learn how such methodologies and abstractions are used to communicate with coworkers and clients about the analysis and design. Because communication is an essential skill in large system development, students are expected to produce documents and presentations of professional quality and depth. Prerequisites: Completion of all Fundamental Skills and COMP 055 with a "C-" or better. (Spring, odd years).

COMP 135. Human-Computer Interface Design. 3 Units.
Human-Computer Interface (HCI) Design focuses on the relationship between humans and computers or other physical devices. This course helps students develop an understanding of the common problems in designing these interfaces and presents a set of design techniques to ensure that designs are both useful and useable. Prerequisite: Completion of all Fundamental Skills. Junior standing. (Spring, odd years).

COMP 137. Parallel Computing. 3 Units.
Parallel computing is a science which solves a large problem by giving small parts of the problem to many computers to solve and then combining the solutions for the parts into a solution for the problem. This course introduces architectures and implementation techniques to support parallel computation. Students are expected to design and implement an original parallel application as a term project. Prerequisite: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. Corequisite: ECPE 170. (Spring, even years).

COMP 141. Programming Languages. 4 Units.
Topics in evaluation, design, and development of programming languages. Topics include type systems, variables and scope, functions, parameter passing, data hiding and abstractions, recursion, memory allocation, grammars and parsing, compiler architecture, programming paradigms, and comparison of programming languages and environments. Prerequisites: Completion of Fundamental Skills and COMP 053 with a "C-" or better. (Spring, every year).

COMP 147. Computing Theory. 4 Units.
Students study automata, formal languages and computability. Topics include finite state automata, regular languages, pushdown automata, context-free languages, Turing machines; decidability, reducibility, and time complexity that includes NP-completeness and intractability. Prerequisites: Completion of all Fundamental Skills; COMP 047 or ECPE 071 or MATH 074 with a "C-" or better. (Fall, every year).

COMP 151. Artificial Intelligence. 3 Units.
Students study fundamental concepts, techniques and tools used in Artificial Intelligence. Topics include knowledge representation, search techniques, machine learning and problem solving strategies. Also listed as ECPE 151. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. (Fall, odd years).

COMP 153. Computer Graphics. 3 Units.
An introduction to two and three dimensional computer graphics. Basic representations and mathematical concepts, object modeling, viewing, lighting and shading. Programming using OpenGL and other computer graphics applications. Also listed as ECPE 153. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. (Fall, even years).

COMP 155. Computer Simulation. 4 Units.
This course explores digital simulation, in which a model of a system is executed on a computer. The course focuses on modeling methodologies, mathematical techniques for implementing models, and statistical techniques for analyzing the results of simulations. Students develop simulations using both simulation development toolkits and general-purpose programming languages. Also listed as EMGT 155. Prerequisites: Completion of all Fundamental Skills; MATH 037 or MATH 039; MATH 045 or MATH 051, COMP 051 or ENGR 019 with a "C-" or better. (Fall, even years).
COMP 157. Design and Analysis of Algorithms. 4 Units.
Topics for this course include complexity analysis, algorithms for searching, sorting, pattern matching, combinatorial problems, optimization problems, backtracking, algorithms related to number theory, graph algorithms, and the limitations of algorithm power. Prerequisites: Completion of all Fundamental Skills; COMP 047 or MATH 074; COMP 053; MATH 045 or MATH 051 with a "C-" or better. (Fall, every year).

COMP 159. Computer Game Technologies. 4 Units.
This course surveys the technologies and processes used for modern video game development. Course topics include software engineering, media creation and management, hardware interfaces, user interaction, 3D mathematics and common algorithms and data structures to support graphics, physics and artificial intelligence. Prerequisite: Completion of all Fundamental Skills and COMP 055 with a "C-" or better. (Fall, odd years).

COMP 162. Data Analytics Programming. 4 Units.
This course develops programming skills for computational data analysis. The course emphasizes programming for statistical analysis, machine learning and predictive modeling. Other topics include programming packages for handling, preparation, and manipulation of data, as well as visualization tools for exploration and presentation of data and results. The course emphasizes hands-on data and analysis using a variety of real-world data sets and analytical objectives. Prerequisites: Completion of all Fundamental Skills; COMP 051 or COMP 061.

COMP 163. Database Management Systems. 4 Units.
A database management system (DBMS) is a computer application designed for the efficient and effective storage, access and update of large volumes of data. This course looks at such systems from two perspectives. The user-center perspective focuses on how a DBMS is used to build support for a data intensive application. This perspective includes examination of common data models, query languages and design techniques. The system implementation perspective focuses on the policies, algorithms and data structures used to design and implement a DBMS. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. Corequisite: COMP 047 or MATH 074. (Spring, even years).

COMP 173. Operating Systems. 4 Units.
Students are introduced to the fundamental concepts of modern operating systems. Topics include an overview of the computer hardware that supports the operating system, process management, threads, and CPU scheduling. Students also study process synchronization that uses primitive and high-level languages, virtual memory management, file systems, system protection, and distributed systems. Prerequisites: Completion of all Fundamental Skills; COMP 053 and ECPE 170 with a "C-" or better or permission of instructor. (Fall, every year).

COMP 175. System Administration and Security. 3 Units.
Students are introduced to an operating system from an administrator's standpoint. Topics include installation with the proper allocation of disk resources, maintaining the operating system and various subsystems, security issues that include server hardening, host firewalls and network security issues. Students also study account administration in a networked environment, change management and intrusion detection. Prerequisites: Completion of all fundamental skills and familiarity with console-based operating systems commands. Junior standing. (Fall, every year).

COMP 177. Computer Networking. 4 Units.
Topics examined in this course include computer networks and the internet, LAN and WAN architectures, and packet switched networks and routing. Students learn about the 7-layer OSI model and internet protocol stack, socket programming and client/server systems, wireless and security. The course includes a laboratory. Also listed as ECPE 177. Prerequisites: Completion of all Fundamental Skills; COMP 053 and ECPE 170 with a "C-" or better. Junior or Senior standing. (Fall, every year).

COMP 178. Computer Network Security. 3 Units.
This course is an examination of the pervasive security threats related to the Internet, data communications and networking. Topics include TCP/IP protocols, authentication, encryption, malware, cybercrime, and social engineering. Emphasis is on computer and network attack methods, their detection, prevention and analysis, and the integration of the tools and techniques employed in this effort. Includes lab. Prerequisites: Completion of all Fundamental Skills and ECPE 170 or COMP 175 with a "C-" or better. (Spring, every year).

COMP 187. Internship in Computer Science. 1-4 Units.
This internship course offers cooperative employment in a professional computer science environment. The internship requires satisfactory completion of the work assignment and written reports. Prerequisites: Completion of all Fundamental Skills; COMP 055 and ENGR 025 with a "C-" or better. Grading is Pass/No Credit only.

COMP 191. Independent Study. 1-4 Units.
Students create student-initiated projects that cover topics not available in regularly scheduled courses. A written proposal that outlines the project and norms for evaluation must be approved by the department chairperson.

COMP 195. CS Senior Project. 4 Units.
In this course, students synthesize their cumulative computer science knowledge through the development of a computer application. Students will establish design objectives and criteria, analyze solution alternatives and evaluate design performance. Students will then implement, test and evaluate the system. Results will include analysis and design documents, the implemented system, test reports and a presentation and demonstration of the project. Prerequisites: Completion of all Fundamental Skills, Senior Standing, COMP 055 with a "C-“ or better.

COMP 197. Undergraduate Research. 1-4 Units.
Students conduct supervised research that contributes to current active topics in Computer Science. Topics may be selected by the student, related to faculty research, or provided by industrial sponsors. Permission of Undergraduate Research Coordinator.