The College Board

AP Computer Science: Principles

Big Ideas, Key Concepts, and Supporting Concepts

AP Computer Science: Principles is a pilot course under development. It is not an official Advanced Placement course currently being offered by the College Board.

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I. Computing is a creative human activity that engenders innovation and promotes exploration.

A. Innovations enabled by computing significantly affect communication, cognition, and human interaction.
   1. Computing has enhanced communication, fostering new ways to collaborate as well as communicate.
   2. Widespread and effective access to information/data facilitates the identification of problems, and the development and dissemination of solutions to problems.
   3. Computing facilitates exploration and the creation of both expected and unexpected connections in information/data.
   4. The Internet and the web are examples of computing innovations that have a profound impact on society.

B. Innovations enabled by computing lead to the creation of new artifacts that affect humanity in diverse ways.
   1. Computing enables new media for human expression and experience.
   2. Computing both extends traditional forms and fosters the creation of new forms of expression.
   3. Computing innovations may have both beneficial and harmful effects.

C. Innovations enabled by computing raise legal and ethical concerns.
   1. Privacy and security concerns arise in the development and use of computational systems and artifacts.
   2. Technology enables small- and large-scale collection, use, and exploitation of information about, by, and for individuals, groups, and institutions.
   3. Widespread access to digitized information raises questions about intellectual property.

D. Computing is situated within economic, social, and cultural contexts.
   1. Computing innovations both influence and are influenced by the cultures in which they are designed and the cultures in which they are used.
   2. The distribution of computing resources in a global economy raises issues of equity, access, and power.
   3. Social and economic values influence the design and development of computing innovations.

II. Abstraction reduces information and detail to focus on concepts relevant to understanding and solving problems.

A. Computational systems and problems are developed, analyzed, and solved using multiple levels of abstraction.
   1. Abstraction helps manage complexity, allowing people to reason about computation and systems at many levels.
   2. Programming languages, from low to high level, are used in solving computational problems and developing systems.
   3. Computing hardware consists of physical layers, including gates, chips, and components, that can be seen as abstractions.
   4. Abstractions help people analyze and comprehend software systems at many levels, ranging from operating systems to the Internet.

B. Models and simulations use abstraction to raise and answer questions about real or imagined worlds.
   1. Models use different levels of abstraction to represent phenomena.
   2. Scientific hypotheses can be formulated, refined, and tested using models and simulations.
   3. Models and simulations can be used to generate new understanding and knowledge.
   4. Simulations can facilitate extensive and rapid testing of models.
   5. Development and use of models and simulations is facilitated by scientific, mathematical, and computational techniques.

III. Data and information facilitate the creation of knowledge.

A. People use computer programs to process information to gain insight and knowledge.
    1. Computers can be used to find patterns in and test hypotheses about digital information.
    2. Insight and knowledge can result from translating and transforming digital information from one form to another.

B. All digital data is represented using a combination of abstractions built upon finite binary sequences.
    1. The interpretation of a binary sequence depends on how it is used, e.g., an instruction, a number, text, a sound, or an image.
    2. A finite representation is used to model the infinite mathematical concept of a number.
    3. Number bases, including binary and decimal, are abstractions used for reasoning about digital data.

C. Information must be translated into a digital format to be manipulated computationally.
    1. Information flows from many sources including sensors, databases, and human polls.
    2. Information must be stored so that it can be manipulated computationally.
    3. Information is often noisy, which can make processing it challenging.

D. Computational manipulation of information requires consideration of representation, storage, security, and transmission.
    1. There are many possible ways to represent information as digital data, that involve trade-offs including accuracy, speed, and ease of manipulation.
    2. Data is stored in many formats depending on its characteristics including its size and its intended use.
    3. Access to information may be limited due to concerns such as privacy, safety, or for economic reasons.

IV. Algorithms are tools for developing and expressing solutions to computational problems.

A. A computational algorithm is a precise sequence of instructions for a process that can be executed by a computer.
   1. Sequencing, selection, iteration, and recursion are building blocks of algorithms.
   2. Algorithms can be combined to make new algorithms.
   3. Different algorithms can be developed to solve the same problem.

B. Algorithms are expressed using languages.
   1. Languages for algorithms include natural language, visual languages, and textual programming languages.
   2. The language used to express an algorithm can be different than the computer language used to implement the algorithm.
   3. The language used to express an algorithm can affect characteristics such as clarity or readability, but not whether an algorithmic solution exists.

C. Computational problems can be categorized by their complexity.
   1. Tractable problems have efficient computational solutions that run in reasonable time, e.g., a time polynomial in the size of the problem.
   2. Intractable problems cannot be solved computationally for small sized instances in a reasonable time, e.g., the solution is exponential in the size of the input.
   3. There is a class of problems that have no known efficient solution, and solving one such problem would effectively solve all of them, e.g., finding the longest path in a graph.
   4. There are problems that can be solved heuristically, but not optimally in a reasonable time, e.g., packing items to minimize the number of boxes used.
   5. There are problems that cannot be solved using a computer, e.g., the Halting problem.

D. Algorithms are evaluated analytically and empirically.
   1. Algorithms can be evaluated using many criteria, e.g., efficiency, correctness, and clarity.
   2. Different correct algorithms for the same problem can have different efficiencies.
   3. Algorithms that have the same analytical efficiency often run at different speeds when measured empirically.

V. Programming is a creative process that produces computational artifacts.

A. Translating human intention into a computational artifact is part of programming.
   1. Some programs are developed simply for personal reasons: to satisfy curiosity, to express creativity.
   2. Some programming languages and environments are designed to help ensure correctness and manage errors.
   3. Programming requires an understanding of how a computer processes instructions.
   4. Developing programs is an iterative process.
   5. Some programs are developed to help people, businesses, or society.
   6. Programming shares characteristics with art and music and engineering in that it translates human intention into an artifact.

B. Programs are developed and used by people.
   1. Programs can be evaluated from a human perspective on criteria such as readability and usability.
   2. Programs are developed in consultation with users.
   3. Programs can be developed by individuals, by small teams, or by large teams.

C. Programming uses mathematical and logical concepts.
   1. Programming uses numerical concepts including real numbers and integers.
   2. Programming uses applications of logical concepts including Boolean algebra.
   3. Sets and set operations are tools for solving computational problems.
   4. Mathematical and statistical functions are tools for solving computational problems.

D. Modularity and parameterization are techniques for writing programs.
   1. Subprograms are used in programming.
   2. Encapsulation of data, functions, or their combination is used in programming.
   3. Parameterization can be used to generalize a specific solution.
   4. Application Program Interfaces (APIs) and libraries facilitate programming.

VI. Digital devices, systems, and the networks that interconnect them enable and foster computational approaches to solving problems.

A. Networks connect computers, sub-networks, and other networks.
   1. Networks connect computers all over the world.
   2. Computer networks support asynchronous and distributed communication.
   3. Computer networks enable new forms of collaboration.

B. System development requires the application of appropriate design principles.
   1. The use of good design principles in system development makes it easier to scale systems.
   2. Modularization makes systems easier to change.
   3. System design often involves tradeoffs including efficiency and security.
   4. Abstractions and interfaces facilitate system design.

C. Computer systems are composed of input, output, storage, and processing, their relations and interactions.
   1. There are hierarchies of storage devices in computer systems.
   2. Computers and systems compute with different kinds of processors.
   3. Different input and output devices are part of computer systems.

D. Characteristics of a system affect the applications for which it can be used.
   1. Size and speed are characteristics of computer components that affect the applications for which they can be used.
   2. Latency and bandwidth are characteristics of networks that affect the applications for which they can be used.
   3. Changes in the characteristics of a system can require changes in the design of associated algorithms and programs.

VII. Computing enables innovation in other fields including mathematics, science, social science, humanities, arts, medicine, engineering, and business.

A. Computing enables innovation by automating processes.
   1. Financial markets, transactions, and predictions have been transformed by automation.
   2. Automation of the processes for tracking and processing goods has enabled innovation from both business and consumer standpoints.
   3. Automation of processes for the delivery of digital information has transformed markets for news, music, movies, literature and other cultural phenomena.

B. Computational modeling fosters innovation and knowledge.
   1. Computation enables people to make better predictions about dynamic systems.
   2. Computation enhances understanding of complex natural and human systems.
   3. Computation enables people to build real and virtual organizations and infrastructures.

C. Computational approaches and data analysis enable innovation.
   1. Analyzing large amounts of data using appropriate algorithms leads to new discoveries in many fields.
   2. Data analysis can reveal patterns that further knowledge and understanding.
   3. Computation enables discovering and understanding by allowing people to visualize information and data.

D. Computing enables innovation by providing access to and sharing of information.
   1. Online sharing of information enables discovery and new forms of collaboration.
   2. Online search of information enables new discoveries and understanding.