



The College Board

# *Computer Science: Principles*

Computational Thinking  
Practices

Big Ideas, Key Concepts, and  
Supporting Concepts

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*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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## ***Computer Science: Principles*** **Computational Thinking Practices**

- 1. Connecting Computing**
  - a. Identification of impacts of computing.
  - b. Description of connections between people and computing.
  - c. Explanation of connections between computing concepts.
  
- 2. Developing computational artifacts**
  - a. Creation of an artifact with a practical, personal, or societal intent.
  - b. Selection of appropriate techniques to develop a computational artifact.
  - c. Use of appropriate algorithmic and information-management principles.
  
- 3. Abstracting**
  - a. Explanation of how data, information, or knowledge are represented for computational use.
  - b. Explanation of how abstractions are used in computation or modeling.
  - c. Identification of abstractions.
  - d. Description of modeling in a computational context.
  
- 4. Analyzing problems and artifacts**
  - a. Evaluation of a proposed solution to a problem.
  - b. Location and correction of errors.
  - c. Explanation of how an artifact functions.
  - d. Justification of appropriateness and correctness.
  
- 5. Communicating**
  - a. Explanation of the meaning of a result in context.
  - b. Description using accurate and precise language, notation, or visualizations.
  - c. Summary of purpose.
  
- 6. Working effectively in teams**
  - a. Application of effective teamwork practices.
  - b. Collaboration of participants.
  - c. Production of artifacts that depend on active contributions from multiple participants.

***Computer Science: Principles***  
**Big Ideas, Key Concepts, Supporting Concepts**

- I. **Creativity:** Computing is a creative activity.
  - A. Computing fosters the creation of artifacts.
    - 1. Computing enables people to create digitally—including creating knowledge, tools, expressions of ideas, and solutions to problems.
    - 2. Computing enables people to translate intention into digital artifacts.
  - B. Computing fosters creative expression.
    - 1. Computing extends traditional forms of human expression and experience.
    - 2. Computing fosters the creation of new forms of expression.
    - 3. Computing enables creative exploration that informs and inspires.
  - C. Programming is a creative process.
    - 1. Some programs are developed to satisfy personal curiosity or for creative expression.
    - 2. Some programs are developed to solve problems, develop new knowledge, or help people, organizations, or society.

- II. **Abstraction:** Abstraction reduces information and detail to facilitate focus on relevant concepts.
  - A. A combination of abstractions built upon binary sequences can be used to represent all digital data.
    - 1. The interpretation of a binary sequence depends on how it is used (e.g., instruction, number, text, sound, or 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.
  - B. Multiple levels of abstraction are used in computation.
    - 1. Binary data is processed by physical layers of computing hardware, including gates, chips, and components.
    - 2. Programming languages, from low to high level, are used in developing software.
    - 3. Applications and systems are designed, developed, and analyzed using levels of hardware, software, and conceptual abstractions.
  - C. Models and simulations use abstraction to raise and answer questions.
    - 1. People use models and simulations to generate new understanding and knowledge.
    - 2. Models use different levels of abstraction to represent phenomena.
    - 3. Hypotheses can be formulated, refined, and tested using models and simulations.
    - 4. Simulations can facilitate extensive and rapid testing of models.

- III. **Data:** 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, digitally represented information.
    - 2. Insight and knowledge can result from translating and transforming digitally represented information.
  
  - B. Computing facilitates exploration and the discovery of connections in information.
    - 1. *Big Data* (use of large datasets) provides new opportunities and new challenges for extracting information and knowledge.
    - 2. Scalability, of systems and analytical approaches, is an important consideration when datasets are large.
    - 3. Metadata can increase the effective use of data or a dataset by providing additional information about various aspects of that data.
  
  - C. Computational manipulation of information requires consideration of representation, storage, security, and transmission.
    - 1. There are trade-offs involved in the many possible ways to represent digital and non-digital information as digital data.
    - 2. Data is stored in many formats depending on its characteristics—such as size and intended use—so that it can be manipulated computationally.

- IV. **Algorithms:** Algorithms are used to develop and express solutions to computational problems.
- A. An 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, pseudo-code, and visual and textual programming languages.
    - 2. The language used to express an algorithm can be different from the programming language used to implement the algorithm.
    - 3. Different languages are better suited for expressing different algorithms.
    - 4. The language used to express an algorithm can affect characteristics such as clarity or readability, but not whether an algorithmic solution exists.
  - C. Algorithms can solve many, but not all, problems.
    - 1. Many problems can be solved in a reasonable time.
    - 2. Some problems can be solved, but heuristic approaches are necessary to solve them in a reasonable time.
    - 3. Some problems cannot be solved using any algorithm.
  - 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.

- V. **Programming:** Programming enables problem solving, human expression, and creation of knowledge.
  - A. Programs are written to execute algorithms.
    - 1. Programming requires an understanding of how instructions are processed.
    - 2. Programs are executed to automate processes.
    - 3. A single program can be run multiple times and on many machines.
    - 4. Executable programs increase the scale of problems that can be addressed.
  - B. Programming is facilitated by appropriate abstractions.
    - 1. Functions are re-usable programming abstractions.
    - 2. Parameterization can be used to generalize a specific solution.
    - 3. Data abstraction provides a means of separating behavior from implementation.
    - 4. Application Program Interfaces (APIs) and libraries simplify complex programming tasks.
  - C. Programs are developed and used by people.
    - 1. Developing programs is an iterative process.
    - 2. Finding and eliminating errors is an essential part of developing programs.
    - 3. Programs are developed in consultation with users.
    - 4. Documentation is a necessary part of developing maintainable programs.
    - 5. Programs are evaluated for their correctness and style.
  - D. 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.

- VI. **Internet:** The Internet pervades modern computing.
  - A. The Internet is a network of autonomous systems.
    - 1. The Internet connects devices and networks all over the world.
    - 2. The Internet and the systems built on it facilitate collaboration.
    - 3. The Internet is built on evolving standards including those for addresses and names.
  - B. Characteristics of the Internet and the systems built on it influence their use.
    - 1. Hierarchy and redundancy help systems scale.
    - 2. Interfaces and protocols enable widespread use.
    - 3. The size and speed of systems affect their use.
  - C. Cybersecurity is an important concern for the Internet and systems built on it.
    - 1. The trust model of the Internet involves tradeoffs.
    - 2. Cryptography is essential to many models of cybersecurity.
    - 3. Implementing cybersecurity has software, hardware, and human components.



- VII. **Impact:** Computing has global impacts.
- A. Computing affects communication, interaction, and cognition.
    - 1. Computing enhances communication, fostering new ways to communicate and collaborate.
    - 2. Widespread access to information facilitates identification of problems, development of solutions, and dissemination of results.
    - 3. Computing enhances human capabilities (e.g., through the use of cyber-physical systems and assistive technologies).
    - 4. The Internet and the web have a profound impact on society.
  - B. Computing enables innovation in nearly every field.
    - 1. Computational approaches and data analysis enable innovation.
    - 2. Computing enables innovation by providing access to, and sharing of, information.
  - C. Computing has both beneficial and harmful effects.
    - 1. Innovations enabled by computing raise legal and ethical concerns.
    - 2. Privacy and security concerns arise in the development and use of computational systems and artifacts.
    - 3. Technology enables collection, use, and exploitation of information about, by, and for individuals, groups, and institutions.
    - 4. 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 contexts in which they are designed and the contexts in which they are used.
    - 2. The global distribution of computing resources raises issues of equity, access, and power.