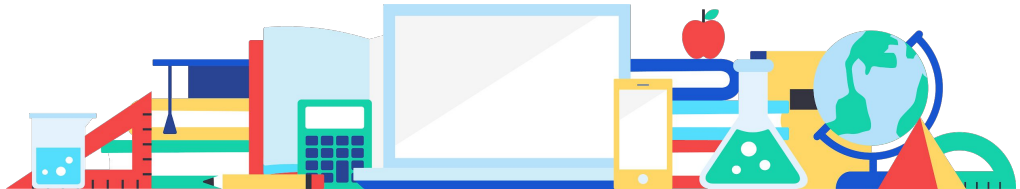
# AP Computer Science Principles

**Updated December 2023**



# This training

AP Computer Science Principles Course and Exam Description

## By the end of this guide you will

**Understand what students need to know**

This training isn't intended to teach you the entire AP course, but instead ensure that you know, *and can do*, most things that are expected of students enrolled in the course. You do NOT need to have taken this course to coach it! If you have a general understanding of any programming language along with the topics covered in this training, you should be able to help students with most assignments.

**Have access to resources to review**

Throughout the guide you'll see resources hyperlinked to help you review specific content. You'll notice no reference to specific coding language. AP CSP courses vary in programming language, if your student requests specific help in a language you're not familiar with feel free to let them know to request a different coach. You will need to be familiar with pseudocode.

**Understand the evaluation of students**

This training will also review the AP exam and Create Performance task that will account for a position of students' grades, as well as empower them to earn college credit if they do well. It's important for you to understand what students are working towards in the course as many will ask for help preparing for this.

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# Creative Development

# Creative Development

## What do students need to know or be able to do?

- ➔ Determine a program's function and purpose through investigation and data and explain how code a segment or programs function
  - ◆ The purpose of computing innovations is to solve problems or to pursue interests through creative expression.
  - ◆ Students should be able to determine or define the behavior of a program, program inputs, events, and outputs.
    - Program: is a collection of program statements that performs a specific task when run by a computer.
    - Behavior: how a program functions during execution and is often described by how a user interacts with it.
    - Inputs: data sent to a computer for processing by a program. Inputs can come from a user or other programs [subprograms]
    - Events: associated with an action and supplies input data to a program (such as a "key press or mouse click")
      - ○ In event-driven programming [e.g. when interacting with a website], program statements are executed when triggered rather than through the sequential flow of control.
    - Outputs: are any data sent from a program to a device or another program.

AP Computer Science Principles Course and Exam Description

# Creative Development

## What do students need to know or be able to do?

- Identify and correct errors in algorithms and programs, including error discovery through testing.
  - A program should be “robust” meaning that it should work for a variety of inputs and situations.
  - A logic error is a mistake in the algorithm or program that causes it to behave incorrectly or unexpectedly.
  - A syntax error is a mistake in the program where the rules of the programming language are not followed.
  - A run-time error is a mistake in the program that occurs during the execution of a program. Programming languages define their own runtime errors.
  - An overflow error is an error that occurs when a computer attempts to handle a number that is outside of the defined range of values.
  - The following are effective ways to find and correct errors: test cases, hand tracing, visualizations, debuggers, adding extra output statement(s)
- Determine and design an appropriate method or approach to achieve the purpose through program development
  - The following phases are commonly used when developing a program: investigating and reflecting, designing, prototyping, testing
  - Program development is typically Incremental. In “top/down” or “divide and conquer” design, larger problems are successively broken up into smaller problems which can be solved independently and their solutions combined to solve the larger problem. If the smaller problems are not easily solved they may in turn be divided into still smaller problems and so on. In “bottom/up design” the process is essentially the same except one starts with simpler and builds up to more complex. In practice both techniques may be combined.

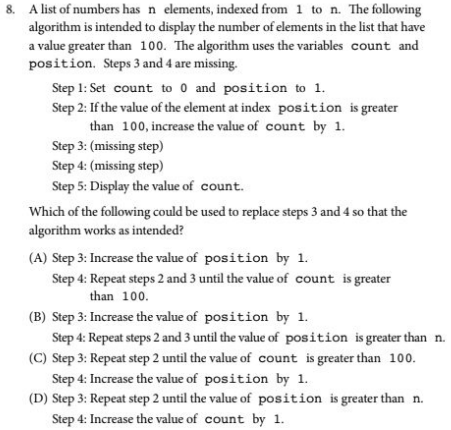
AP Computer Science Principles Course and Exam Description

# Creative Development

## How will this skill be tested?

- ➔ Students must create a program for the “Create Performance Task”
  - ◆ They choose their project topic but must include specific elements like lists and procedures
- ➔ Students will also read, evaluate, and fix errors in other’s code on the AP exam
- ➔ AP Computer Science Principles allows a lot of flexibility in programming language, to test students ability they use pseudocode. As a coach you should be able to read pseudocode.

**Example Exam Question**



8. A list of numbers has `n` elements, indexed from `1` to `n`. The following algorithm is intended to display the number of elements in the list that have a value greater than `100`. The algorithm uses the variables `count` and `position`. Steps 3 and 4 are missing.

   Step 1: Set `count` to `0` and `position` to `1`.
   Step 2: If the value of the element at index `position` is greater than `100`, increase the value of `count` by `1`.
   Step 3: (missing step)
   Step 4: (missing step)
   Step 5: Display the value of `count`.

   Which of the following could be used to replace steps 3 and 4 so that the algorithm works as intended?

   (A) Step 3: Increase the value of `position` by `1`.
   Step 4: Repeat steps 2 and 3 until the value of `count` is greater than `100`.
   (B) Step 3: Increase the value of `position` by `1`.
   Step 4: Repeat steps 2 and 3 until the value of `position` is greater than `n`.
   (C) Step 3: Repeat step 2 until the value of `count` is greater than `100`.
   Step 4: Increase the value of `position` by `1`.
   (D) Step 3: Repeat step 2 until the value of `position` is greater than `n`.
   Step 4: Increase the value of `count` by `1`.

[Example Create Performance Tasks]
[Example AP Test Questions 2023]

# Data

# Data

## What do students need to know or be able to do?

- Understand and Use Binary Numbers
  - Explain how data can be represented using bits.
  - Calculate the binary (base 2) equivalent of a positive integer (base 10) and vice versa.
  - Compare and order binary numbers.
  - Explain how abstraction manages complexity
- Compare Data Compression
  - Compare lossless and lossy data compression algorithms to determine which is best in a particular context.
- Extract Information from Data
  - Explain how knowledge can be generated from data.
  - Explain how metadata can be used to extract information from data.
  - Identify the challenges associated with processing data
- Use Programs with Data
  - Extract information from data using a program: Students should know that programmers can use programs to filter and clean digital data, thereby gaining insight and knowledge. Combining data sources, clustering data, and classifying data are parts of the process of using programs to gain insight and knowledge from data.

Khan Academy: Digital Information
Khan Academy: Data analysis

# Data

## How will this skill be tested?

- ➔ In the exam students will
  - ◆ Analyze scenarios that describe data and metadata and identify extractable information, as well as propose programming processes for data manipulation
  - ◆ Compare compression algorithms and select the most suitable

**Example Exam Question**

A database consists of groups and their members. The members in each group are represented as a list of first and last names. Metadata for each group specifies whether the list of members are sorted by last name then first name. For which of the following goals would the metadata be useful.

(A) Find the 10 largest groups
(B) Which groups does Mary Programmer belong to.
(C) Which groups have the most members with first name David
(D) Find the total number of groups

Example Exam Questions
Example AP Test Questions 2023

# Algorithms and Programming

# Algorithms and Programming

Khan Academy: Programming 101

## What do students need to know or be able to do?

- Represent a value with a variable.
  - A variable is an abstraction inside a program that can hold a value. Each variable has associated data storage that represents one value at a time, but that value can be a list or other collection that in turn contains multiple values.
  - Some programming languages "require variables to have a specified "type" which restricts the values the variable can represent to values of the specified type. Thus a variable of type “integer” can only represent integer values and a variable of type “string” can only represent strings. Languages with this restriction are said to be “strongly typed.” Strong typing helps the programmer avoid errors like trying to multiply a string by an integer.
- Determine the value of a variable as a result of an assignment.
  - The assignment operator allows a program to change the value represented by a variable.
  - The exam reference sheet provides the ← operator to use for assignment.
- Data Abstraction
  - Represent a list or string using a variable.
    - A list is an ordered sequence of elements. For example, [value1, value2, value3, ...] describes a list where value1 is the first element. List types typically include operations to determining the length of the list (which may be 0), append a new element to the end of the list, and determine the value of the element at position i. List types may also include operations to modify or delete the element at a given position and insert a new element before a given position.
    - For strongly typed languages the type of a list variable will also specify the type of its elements, e.g., List(integer) or List(string) oe List(List(string)).
  - Defining element, index
  - Develop algorithms using lists to store multiple elements.
  - Explain how the use of data abstraction manages complexity in program code. i.e. Data abstractions manage complexity in programs by giving a collection of data a name without referencing the specific details of the representation.

# Algorithms and Programming

Khan Academy: Programming 101
Khan Academy: Binary Search

## What do students need to know or be able to do?

- Write and evaluate mathematical expressions
  - Express an algorithm that uses sequencing without using a programming language.
  - Represent a step-by-step algorithmic process using sequential code statements, i.e. where statements are executed one after the other in the order in which they are listed in the algorithm.
  - There are two kinds of instructions in a general algorithm.
    - "Operations" evaluate expressions and possibly modify variables.
    - "Control instructions" may affect the order in which instructions are executed. "Selection" causes control to select from two or more alternatives. "Iteration" causes control repeat a block of statements in a loop "until" or "as long as" some condition is satisfied.
    - Algorithms can be represented with a boxes and arrows diagram where boxes represent operations and arrows represent control flow.
    - In An algorithm is a finite set of instructions that accomplish a specific task. Every algorithm can be constructed using combinations of sequencing, selection, and iteration.
- Evaluate expressions that manipulate strings
- Write and evaluate boolean expressions using relational operators.
- Writing and evaluating results of various statements including conditionals (selection), nested conditionals, iteration
- Write or evaluate expressions that use list indexing and list procedures, including iteration statements to traverse a list.
- Explain the requirements necessary to complete a binary search.

# Algorithms and Programming

## What do students need to know or be able to do?

- Call and develop procedures
- Select appropriate libraries or existing code segments to use in creating new programs
  - A "library," is a collection of pre-written and reusable code, functions, classes, or modules that programmers can use to perform common tasks or solve problems without having to write the code from scratch.
- Use random number generators to simulate variability in models of real-world systems.
- Explain how computer simulations can be used to represent real-world phenomena or outcomes.
- How to create, compare, combine, modify, algorithms
- Explain what is meant by algorithmic efficiency and why an algorithm with exponential efficiency is probably not “reasonable.”.
- Explain the concept of undecidable problems in computer science.
- Identify situations where a heuristic solution may be more appropriate.

Khan Academy: Programming 101
Khan Academy: Simulations
Khan Academy: Algorithms

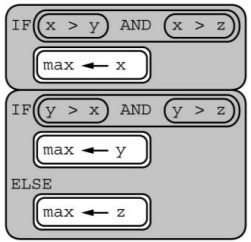
# Algorithms and Programming

## How will this skill be tested?

- ➔ AP Exam requires students to assess code outcomes using pseudocode.
- ➔ The “create performance task” asks students create a program with abstraction. Students need to explain their code in detail on the written responses section of the exam.

### Example Question

9. The following code segment is intended to set `max` equal to the maximum value among the integer variables `x`, `y`, and `z`. The code segment does not work as intended in all cases.




Which of the following initial values for `x`, `y`, and `z` can be used to show that the code segment does not work as intended?

(A) `x = 1, y = 2, z = 3`
(B) `x = 1, y = 3, z = 2`
(C) `x = 2, y = 3, z = 1`
(D) `x = 3, y = 2, z = 1`

[Exam Prep from Fiveable Example AP Test Questions 2023]

# Computer Systems and Networks

# Computer Systems and Networks

Khan Academy: The Internet

## What do students need to know or be able to do?

- Explain how computing devices work together in a network
- Define computing device, system, network, routing, bandwidth
  - A computing device is a physical artifact that can run a program. Some examples include computers, tablets, servers, routers, and smart sensors.
  - A computing system is a group of computing devices and programs working together for a common purpose.
  - A computer network is a group of interconnected computing devices capable of sending or receiving data.
  - Routing is the process of finding a path from sender to receiver.
  - The bandwidth of a computer network is the maximum amount of data that can be sent in a fixed amount of time.
- Explain how the Internet works
  - The Internet is a computer network consisting of interconnected networks that use standardized, open (nonproprietary) communication protocols.
  - A protocol is an agreed-upon set of rules that specify the behavior of a system.
  - Access to the Internet depends on the ability to connect a computing device to an Internet Connected device.

# Computer Systems and Networks

Khan Academy: The Internet

## What do students need to know or be able to do?

- Explain how data are sent through the Internet via packets: Information is passed through the Internet as a data stream. Data streams contain chunks of data, which are encapsulated in packets.
- Describe the differences between the Internet and the World Wide Web: The World Wide Web is a system of linked pages, programs, and files that uses the Internet.
- Describe the benefits of fault tolerance.
  - When a system can support failures and still continue to function, it is called fault-tolerant. This is important because it allows users to continue to use the network. The redundancy of routing options between two points increases the reliability of the Internet and helps it scale to more devices and more people. Scalable is defined as the ability of an organization (or a system, such as a computer network) to perform well under an increased or expanding workload. A system that scales well will be able to maintain or increase its level of performance even as it is tested by larger and larger operational demands.
- Explain how a given system is fault-tolerant.
  - Redundancy is the inclusion of extra components that can be used to mitigate failure of a system if other components fail. One way to accomplish network redundancy is by having more than one path between any two connected device. If a particular device or connection on the Internet fails, subsequent data will be sent via a different route, if possible.
- Identify vulnerabilities to failure in a system.

# Computer Systems and Networks

Khan Academy: Parallel and distributed computing

## What do students need to know or be able to do?

- Compare solutions and determine the efficiency of solutions that use sequential, parallel, and distributed computing.
  - Sequential computing is a computational model in which operations are performed in order one at a time.
  - Parallel computing is a computational model where the program is broken into multiple smaller sequential computing operations, some of which are performed simultaneously.
  - Distributed computing is a computational model in which multiple devices are used to run a program.
  - Comparing efficiency of solutions can be done by comparing the time it takes them to perform the same task.
- Describe benefits and challenges of parallel and distributed computing.
  - Solutions that use parallel computing can scale more effectively than solutions that use sequential computing.
  - Distributed computing allows problems to be solved that could not be solved on a single computer because of either the processing time or storage needs involved. It also allows much larger problems to be solved quicker than they could be solved using a single computer.

# Computer Systems and Networks

## How will this skill be tested?

- ➔ Students will be asked to select which scenario best explains how information could be passed via the Internet.
- ➔ They will also need to express how designing systems to include redundancy helps make networks fault-tolerant.

**Example Exam Question**

**4.** Why is Internet routing usually dynamic?

- A. So that if a path on the route is congested or not working, a new path can be assigned
- B. So that it can speed up or slow down as necessary to avoid data congestion
- C. So that new routes can be tested in beta mode before being available globally
- D. So that as noise on a route becomes louder, traffic can be limited until it reaches acceptable levels

Khan Academy: The Internet Example AP Test Questions 2023

# Impact of Computing

# Impact of Computing

## What do students need to know or be able to do?

- Describe the impact of a computing innovation, including explaining how an effect of a computing innovation can be both beneficial and harmful.
- Explain how a computing innovation can have an impact beyond its intended purpose.
  - Example: The World Wide Web was originally intended only for rapid and easy exchange of information within the scientific community.
- Describe issues that contribute to the digital divide.
  - The “digital divide” refers to differing access to computing devices and the Internet, based on socioeconomic, geographic, or demographic characteristics.
- Explain how bias exists in computing innovations: Computing innovations can reflect existing human biases because of biases written into the algorithms or biases in the data used by the innovation.
- Explain crowdsourcing: the practice of obtaining input or information from a large number of people via the Internet.
- Explain how the use of computing can raise legal and ethical concerns.
- Evaluate the use of computing based on legal and ethical factors.

Khan Academy: The digital divide
Khan Academy: Bias in machine learning

# Impact of Computing

## What do students need to know or be able to do?

- Material created on a computer is the intellectual property of the creator or an organization. Measures should be taken to safeguard intellectual property. The use of material created by someone other than you should always be cited.
  - Some examples of legal ways to use materials created by someone else include:
    - Creative Commons—a public copyright license that enables the free distribution of an otherwise copyrighted work.
    - Open source—programs that are made freely available and may be redistributed and modified.
    - Open access—online research output free of any and all restrictions on access and free of many restrictions on use, such as copyright or license restrictions
- Describe the risks to privacy from collecting and storing personal data on a computer system.
  - Information placed online can be used in ways that were not intended and that may have a harmful impact. For example, PII can be used to stalk or steal the identity of a person or to aid in the planning of other criminal acts. Personally identifiable information (PII) is information about an individual that identifies, links, relates, or describes them. Examples of PII include: name, phone number, Social Security number

Khan Academy: Digital copyright and licenses
Khan Academy: Online data security

# Impact of Computing

## What do students need to know or be able to do?

- ➔ Explain how computing resources can be protected
  - ◆ Authentication measures, like strong passwords and multifactor authentication, protect devices and information from unauthorized access.
  - ◆ Encryption is the process of encoding data to prevent unauthorized access. Decryption is the process of decoding the data. Two common encryption approaches are: symmetric key and public key encryption
  - ◆ Computer virus and malware scanning software can help protect a computing system against infection.
  - ◆ Users can control the permissions programs have for collecting user information.
- ➔ Explain how unauthorized access to computing resources is gained.
  - ◆ Data sent over public networks can be intercepted, analyzed, and modified. One way that this can happen is through a rogue access point.
  - ◆ Unsolicited emails, attachments, links, and forms in emails can be used to compromise the security of a computing system.
  - ◆ Phishing and keylogging are also examples

Khan Academy: Online data security

# Impact of Computing

## How will this skill be tested?

- On the end-of-course exam, students will be presented with a passage about a computing innovation and will be asked a series of questions about data and the effects of the computing innovation.

**Example Exam Questions**

- Passage-based question 1

Khan Academy: Exam Preparation
Khan Academy: Practice passage-based questions
Example AP Test Questions 2023

# Exam & Create Performance Task

# Exam

## Overview AP Exams

**What is AP?**

Advanced Placement is a specific type of course created by the nonprofit organization College Board. Students take these courses to prepare for college level coursework.

**What is an AP exam & why is it important?**

Students are able to take a national exam in April or May to demonstrate their mastery of course content. **These exams are important because, depending on the student's score they can be granted college credit for the course!** Usually public colleges and universities require a 3 out of 5, while other colleges may require a 4 or 5. Some high school teachers also incorporate a student's AP score into their final grade.

**Unique Format of AP Computer Science Principles Exam**

The AP Computer Science Principles Exam consists of the "Create performance task" and an end-of-course AP Exam. The Create performance task requires at least 9 hours of dedicated class time for students to complete. The end-of-course exam is 3 hours long and includes 70 multiple-choice questions and four written response prompts related to the Create performance task.

# Exam

## AP Computer Science Principles Exam

**Format**

- ➔ 3 hour exam in May
- ➔ Section 1 (2 hours): 70 multiple choice questions (70% of exam score) Practice Questions
  - ◆ 57 single-select and 8 multiselect multiple-choice questions
    - Conceptual questions (how something works or causes and effects)
    - Coding problems (analyze lines of code, check code for errors)
    - Robot's Path (which code will move the robot)
    - Binary conversion (test knowledge of binary numbers)
  - ◆ 5 single-select multiple-choice questions with reading passage about a computing innovation
- ➔ Section 4 (1 hour on exam day): 4 written responses about the student's "Create performance task" (see next slide for more on the performance task) Sample Questions
  - ◆ Question about: Program Design, Function, and Purpose
  - ◆ Question about: Algorithm Development
  - ◆ Question about: Errors and Testing
  - ◆ Question about: Data and Procedural Abstraction
  - ◆ The longest of these responses is 300 words at most, and the word count total is 750 words
- ➔ Reference sheet provided

**Scoring**

- ➔ The exam is a scaled score that is converted into 1-5 final score
- ➔ There is no penalty for wrong answers so students should complete each question

**Sample Questions videos**

# Create performance task

## AP Computer Science Principles “Create performance task”

**What is the “Create performance task”?**

Students will develop a computer program of their choice during the course (students have at least 9 hours of in-class time for this task) and an end-of-course written response section where students demonstrate their understanding of their personal Create performance task by answering four prompts. They have access to a Personalized Project Reference (like a cheat sheet) to look at the day of the exam.

**Requirements for the task**

- Student-developed program code must...
  - Have a user interface with both input and output
  - Create and use a list of information
  - At least one procedure that contributes to the program’s intended purpose
  - An algorithm that includes sequencing, selection, and iteration that is in the body of the selected procedure
  - Calls to the student-developed procedure
- Video of the program running including...
  - Input to the program
  - One aspect of the functionality of the program
  - Output produced by the program

# Create performance task

## AP Computer Science Principles “Create performance task”

**Scoring (Rubric)**

- Each component of the performance task is graded 0-1 for a final score of 6, this will account for 30% of the final AP exam grade
  - **Program Purpose and Function**: Students should be able to describe the overall purpose of the program, the functionality the video shows and the input and output of the program in the video.
  - **Data Abstraction**: The code segments should show storing data in a list and how that list is used. Students should be able to name the variable representing the list and what data the list represents
  - **Managing complexity**: Students will have to explain how the code uses lists to manage complexity.
  - **Procedural Abstraction**: Students will describe a procedure with one parameter that has an effect on the functionality and where it is called.
  - **Algorithm Implementation**: Students will have to explain their algorithm (that includes sequencing, selection, iteration) in enough detail that someone else could recreate it.
  - **Testing:** Students will describe two calls to the procedure written earlier, the conditions they test, and the results.

**Examples**

- CodeHS
- Code.org video
- 15 examples

# Code.org

# Code.org partnership

## Code.org and UPchieve are working together!

**Pilot Overview**

- ➔ We've partnered with Code.org to offer personalized tutoring to help underrepresented and underserved students improve their understanding and performance in AP CSP! This means the majority of students you'll work with will be using their curriculum.

**Lesson types**

- ➔ Programming lessons
- ➔ Non-programming lessons
- ➔ Project lessons

**Resources**

- ➔ CSP Course: Create a teacher account, using UPchieve as your "school" to access full curriculum for free!
- ➔ Overview of curriculum & tools