AP Computer Science Principles End-of-Course Exam

Weight: 60% of the AP Computer Science Principles final score

Hours: 2 hours

Date: May (in the AP Exam administration window)

Note: The end-of-course exam will be administered using the same procedures and guidelines as all other AP Exams.

Overview

The AP Computer Science Principles End-of-Course Exam is composed of two types of multiple-choice questions:

- **Single-select multiple-choice questions:** Students select one answer from among four options.
- **Multiple-select multiple-choice questions:** Students select two answers from among four options.

Multiple-choice questions on the exam are classified according to learning objectives within each big idea in the AP Computer Science Principles curriculum framework. Some exam questions may be aligned to more than one learning objective. For example, a question on programming might implement an algorithm and contain abstractions. In any case, a primary learning objective is identified and is used to ensure the appropriate distribution of test questions in the AP Exam. The table below intends to show the approximate percentages of test question per big idea. Teachers should examine this table as one of many other important features of the course to plan their instruction.

Big Ideas	Approximate Percentage of Multiple-Choice Questions
Big Idea 1: Creativity	---
Big Idea 2: Abstraction	19%
Big Idea 3: Data and Information	18%
Big Idea 4: Algorithms	20%
Big Idea 5: Programming	20%
Big Idea 6: The Internet	13%
Big Idea 7: Global Impact	10%

The AP Computer Science Principles Exam Reference Sheet is found in the Reproducibles for Students section and provides programming instructions and explanations to help students understand questions they will see on the AP Exam.

Sample Exam Questions

To elicit evidence of student achievement of the course learning objectives, exam questions assess both the application of the computational thinking practices and knowledge of the big ideas and enduring understandings. They may address content from more than one essential knowledge statement. Exam questions may be accompanied by nontextual stimulus material such as diagrams, charts, or other graphical illustrations. The sample questions that follow illustrate the relationship between the curriculum framework and the AP Computer Science Principles End-Of-Course Exam and serve as examples of the types of questions that will appear on the assessment. Each question is accompanied by a table containing the enduring understandings, learning objective, computational thinking practices, and essential knowledge statements that the question addresses. The answers can be found in a table after the sample exam questions.

1. A video-streaming Web site uses 32-bit integers to count the number of times each video has been played. In anticipation of some videos being played more times than can be represented with 32 bits, the Web site is planning to change to 64-bit integers for the counter. Which of the following best describes the result of using 64-bit integers instead of 32-bit integers?

   (A) 2 times as many values can be represented.

   (B) 32 times as many values can be represented.

   (C) 2^{32} times as many values can be represented.

   (D) 32^2 times as many values can be represented.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data.	**2.1.1** Describe the variety of abstractions used to represent data. [P3]	**P3** Abstracting	**2.1.1A** **2.1.1B** **2.1.1E**

2. A programmer completes the user manual for a video game she has developed and realizes she has reversed the roles of goats and sheep throughout the text. Consider the programmer's goal of changing all occurrences of "goats" to "sheep" and all occurrences of "sheep" to "goats." The programmer will use the fact that the word "foxes" does not appear anywhere in the original text.

   Which of the following algorithms can be used to accomplish the programmer's goal?

   (A) First, change all occurrences of "goats" to "sheep."
   Then, change all occurrences of "sheep" to "goats."

   (B) First, change all occurrences of "goats" to "sheep."
   Then, change all occurrences of "sheep" to "goats."
   Last, change all occurrences of "foxes" to "sheep."

   (C) First, change all occurrences of "goats" to "foxes."
   Then, change all occurrences of "sheep" to "goats."
   Last, change all occurrences of "foxes" to "sheep."

   (D) First, change all occurrences of "goats" to "foxes."
   Then, change all occurrences of "foxes" to "sheep."
   Last, change all occurrences of "sheep" to "goats."

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**4.1.1** Develop an algorithm for implementation in a program. [P2]	**P2** Creating computational artifacts	**4.1.1A** **4.1.1B**

3. ASCII is a character-encoding scheme that uses a numeric value to represent each character. For example, the uppercase letter "G" is represented by the decimal (base 10) value 71. A partial list of characters and their corresponding ASCII values are shown in the table below.

Decimal	ASCII Character
65	A
66	B
67	C
68	D
69	E
70	F
71	G
72	H
73	I
74	J
75	K
76	L
77	M

Decimal	ASCII Character
78	N
79	O
80	P
81	Q
82	R
83	S
84	T
85	U
86	V
87	W
88	X
89	Y
90	Z

ASCII characters can also be represented by hexadecimal numbers. According to ASCII character encoding, which of the following letters is represented by the hexadecimal (base 16) number 56?

(A) A

(B) L

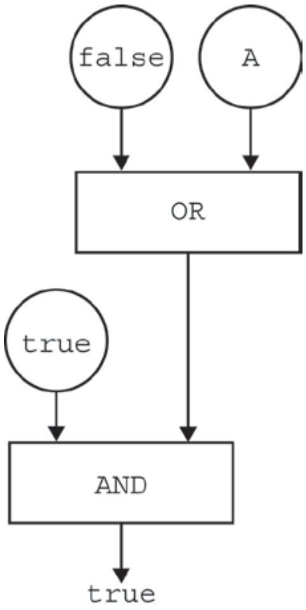
(C) V

(D) Y

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data.	**2.1.1** Describe the variety of abstractions used to represent data. [P3]	**P3** Abstracting	**2.1.1A** **2.1.1C** **2.1.1D** **2.1.1E** **2.1.1G**

SAMPLE EXAM QUESTIONS

4. The figure below shows a circuit composed of two logic gates. The output of the circuit is `true`.



Which of the following is a true statement about input `A`?

(A) Input `A` must be `true`.

(B) Input `A` must be `false`.

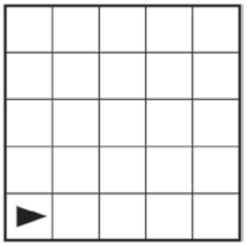
(C) Input `A` can be either `true` or `false`.

(D) There is no possible value of input `A` that will cause the circuit to have the output `true`.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts.	**2.2.3** Identify multiple levels of abstractions being used when writing programs. [P3]	**P3** Abstracting	**2.2.3E** **2.2.3F**

SAMPLE EXAM QUESTIONS

5. The following question uses a robot in a grid of squares. The robot is represented as a triangle, which is initially in the bottom left square of the grid and facing right.

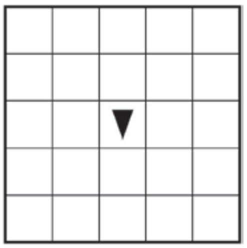


Consider the following code segment, which moves the robot in the grid.

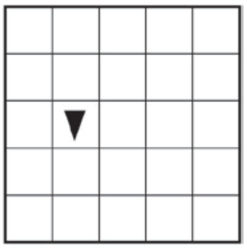
```
n ← 3
REPEAT 3 TIMES
    REPEAT n TIMES
        MOVE_FORWARD
    ROTATE_LEFT
    n ← n - 1
```

Which of the following shows the location of the robot after running the code segment?

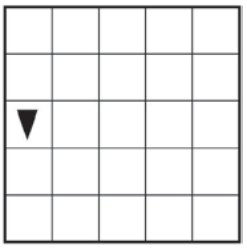
(A)



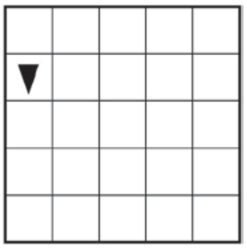
(B)



(C)



(D)



Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.2 People write programs to execute algorithms.	**5.2.1** Explain how programs implement algorithms. [P3]	**P3** Abstracting	**5.2.1A** **5.2.1B** **5.2.1C**

6. Which of the following statements describes a limitation of using a computer simulation to model a real-world object or system?

   (A) Computer simulations can only be built after the real-world object or system has been created.

   (B) Computer simulations only run on very powerful computers that are not available to the general public.

   (C) Computer simulations usually make some simplifying assumptions about the real-world object or system being modeled.

   (D) It is difficult to change input parameters or conditions when using computer simulations.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
2.3 Models and simulations use abstraction to generate new understanding and knowledge.	**2.3.1** Use models and simulations to represent phenomena. [P3]	**P3** Abstracting	**2.3.1A** **2.3.1C** **2.3.1D**

7. A certain social media Web site allows users to post messages and to comment on other messages that have been posted. When a user posts a message, the message itself is considered data. In addition to the data, the site stores the following metadata.

   - The time the message was posted
   - The name of the user who posted the message
   - The names of any users who comment on the message and the times the comments were made

For which of the following goals would it be more useful to analyze the data instead of the metadata?

(A) To determine the users who post messages most frequently

(B) To determine the time of day that the site is most active

(C) To determine the topics that many users are posting about

(D) To determine which posts from a particular user have received the greatest number of comments

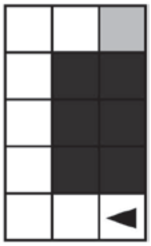
Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
3.2 Computing facilitates exploration and the discovery of connections in information.	**3.2.1** Extract information from data to discover and explain connections or trends. [P1]	**P1** Connecting computing	**3.2.1B** **3.2.1G** **3.2.1H** **3.2.1I**

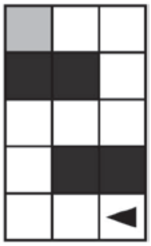
8. The code segment below is intended to move a robot in a grid to a gray square. The program segment uses the procedure `GoalReached`, which evaluates to `true` if the robot is in the gray square and evaluates to `false` otherwise. The robot in each grid is represented as a triangle and is initially facing left. The robot can move into a white or gray square but cannot move into a black region.

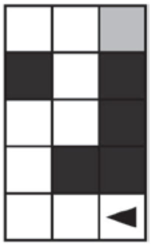
```
REPEAT UNTIL (GoalReached ())
{
   IF (CAN_MOVE (forward))
   {
      MOVE_FORWARD ()
   }
   IF (CAN_MOVE (right))
   {
      ROTATE_RIGHT ()
   }
   IF (CAN_MOVE (left))
   {
      ROTATE_LEFT ()
   }
}
```

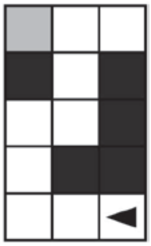
SAMPLE EXAM QUESTIONS

For which of the following grids does the code segment NOT correctly move the robot to the gray square?

(A)


(B)


(C)


(D)


Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. [P4]	**P4** Analyzing problems and artifacts	**4.2.4B**

9. The table below shows the time a computer system takes to complete a specified task on the customer data of different-sized companies.

Task	Small Company (approximately 100 customers)	Medium Company (approximately 1,000 customers)	Large Company (approximately 10,000 customers)
Backing up data	2 hours	20 hours	200 hours
Deleting entries from data	100 hours	200 hours	300 hours
Searching through data	250 hours	300 hours	350 hours
Sorting data	0.01 hour	1 hour	100 hours

Based on the information in the table, which of the following tasks is likely to take the longest amount of time when scaled up for a very large company of approximately 100,000 customers?

(A) Backing up data

(B) Deleting entries from data

(C) Searching through data

(D) Sorting data

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
3.2 Computing facilitates exploration and the discovery of connections in information.	**3.2.2** Determine how large data sets impact the use of computational processes to discover information and knowledge. [P3]	**P3** Abstracting	**3.2.2E** **3.2.2F** **3.2.2H**

10. Consider the code segment below.

```
IF onTime
    DISPLAY "Hello."
ELSE
    IF absent
        DISPLAY "Is anyone there?"
    ELSE
        DISPLAY "Better late than never."
```

If the variables `onTime` and `absent` both have the value `false`, what is displayed as a result of running the code segment?

(A) `Is anyone there?`

(B) `Better late than never.`

(C) `Hello. Is anyone there?`

(D) `Hello. Better late than never.`

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**4.1.1** Develop an algorithm for implementation in a program. [P2]	**P2** Creating computational artifacts	**4.1.1A** **4.1.1C**

11. Under which of the following conditions is it most beneficial to use a heuristic approach to solve a problem?

(A) When the problem can be solved in a reasonable time and an approximate solution is acceptable

(B) When the problem can be solved in a reasonable time and an exact solution is needed

(C) When the problem cannot be solved in a reasonable time and an approximate solution is acceptable

(D) When the problem cannot be solved in a reasonable time and an exact solution is needed

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems.	**4.2.2** Explain the difference between solvable and unsolvable problems in computer science. [P1]	**P1** Connecting computing	**4.2.2A** **4.2.2B** **4.2.2C**

12. Which of the following are true statements about digital certificates in Web browsers?

I. Digital certificates are used to verify the ownership of encrypted keys used in secured communication.

II. Digital certificates are used to verify that the connection to a Web site is fault tolerant.

(A) I only

(B) II only

(C) I and II

(D) Neither I nor II

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
6.3 Cybersecurity is an important concern for the Internet and the systems built on it.	**6.3.1** Identify existing cybersecurity concerns and potential options that address these issues with the Internet and the systems built on it. [P1]	**P1** Connecting computing	**6.3.1H** **6.3.1L** **6.3.1M**

13. There are 32 students standing in a classroom. Two different algorithms are given for finding the average height of the students.

Algorithm A

Step 1: All students stand.

Step 2: A randomly selected student writes his or her height on a card and is seated.

Step 3: A randomly selected standing student adds his or her height to the value on the card, records the new value on the card, and is seated. The previous value on the card is erased.

Step 4: Repeat step 3 until no students remain standing.

Step 5: The sum on the card is divided by 32. The result is given to the teacher.

Algorithm B

Step 1: All students stand.

Step 2: Each student is given a card. Each student writes his or her height on the card.

Step 3: Standing students form random pairs at the same time. Each pair adds the numbers written on their cards and writes the result on one student's card; the other student is seated. The previous value on the card is erased.

Step 4: Repeat step 3 until one student remains standing.

Step 5: The sum on the last student's card is divided by 32. The result is given to the teacher.

Which of the following statements is true?

(A) Algorithm A always calculates the correct average, but Algorithm B does not.

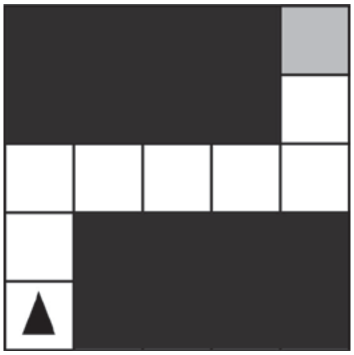
(B) Algorithm B always calculates the correct average, but Algorithm A does not.

(C) Both Algorithm A and Algorithm B always calculate the correct average.

(D) Neither Algorithm A nor Algorithm B calculates the correct average.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. [P4]	**P4** Analyzing problems and artifacts	**4.2.4C**

14. The figure below shows a robot in a grid of squares. The robot is represented as a triangle, which is initially facing upward. The robot can move into a white or gray square but cannot move into a black region.



Consider the procedure `MoveAndTurn` below.

```
PROCEDURE MoveAndTurn (numMoves, numTurns)
    REPEAT numMoves TIMES
        MOVE_FORWARD
    REPEAT numTurns TIMES
        ROTATE_RIGHT
```

Which of the following code segments will move the robot to the gray square?

(A)
```
MoveAndTurn 1, 2
MoveAndTurn 3, 4
MoveAndTurn 0, 2
```

(B)
```
MoveAndTurn 2, 1
MoveAndTurn 4, 1
MoveAndTurn 2, 0
```

(C)
```
MoveAndTurn 2, 1
MoveAndTurn 4, 3
MoveAndTurn 2, 0
```

(D)
```
MoveAndTurn 3, 1
MoveAndTurn 5, 3
MoveAndTurn 3, 0
```

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	**5.3.1** Use abstraction to manage complexity in programs. [P3]	**P3** Abstracting	**5.3.1A** **5.3.1B** **5.3.1D** **5.3.1E** **5.3.1F** **5.3.1G**

15. Biologists often attach tracking collars to wild animals. For each animal, the following geolocation data is collected at frequent intervals.

- The time
- The date
- The location of the animal

Which of the following questions about a particular animal could NOT be answered using <u>only</u> the data collected from the tracking collars?

(A) Approximately how many miles did the animal travel in one week?

(B) Does the animal travel in groups with other tracked animals?

(C) Do the movement patterns of the animal vary according to the weather?

(D) In what geographic locations does the animal typically travel?

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
3.1 People use computer programs to process information to gain insight and knowledge.	**3.1.1** Find patterns and test hypotheses about digitally processed information to gain insight and knowledge. [P4]	**P4** Analyzing problems and artifacts	**3.1.1E**

16. A summer camp offers a morning session and an afternoon session. The list `morningList` contains the names of all children attending the morning session, and the list `afternoonList` contains the names of all children attending the afternoon session.

Only children who attend both sessions eat lunch at the camp. The camp director wants to create `lunchList`, which will contain the names of children attending both sessions.

The following code segment is intended to create `lunchList`, which is initially empty. It uses the procedure `IsFound (list, name)`, which returns `true` if `name` is found in `list` and returns `false` otherwise.

```
FOR EACH child IN morningList
{
   <MISSING CODE>
}
```

Which of the following could replace `<MISSING CODE>` so that the code segment works as intended?

(A)
```
IF (IsFound (afternoonList, child))
{
   APPEND (lunchList, child)
}
```

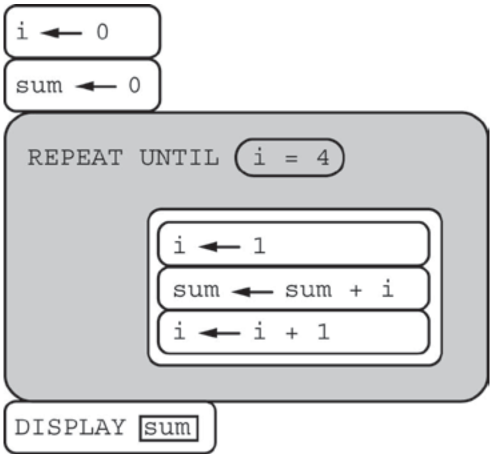
(B)
```
IF (IsFound (lunchList, child))
{
   APPEND (afternoonList, child)
}
```

(C)
```
IF (IsFound (morningList, child))
{
   APPEND (lunchList, child)
}
```

(D)
```
IF ((IsFound (morningList, child)) OR
    (IsFound (afternoonList, child)))
{
   APPEND (lunchList, child)
}
```

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	**5.3.1** Use abstraction to manage complexity in programs. [P3]	**P3** Abstracting	**5.3.1G** **5.3.1K** **5.3.1L**

17. Consider the following program code.



Which of the following best describes the result of running the program code?

(A) The number `0` is displayed.

(B) The number `6` is displayed.

(C) The number `10` is displayed.

(D) Nothing is displayed; the program results in an infinite loop.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.4 Programs are developed, maintained, and used by people for different purposes.	**5.4.1** Evaluate the correctness of a program. [P4]	**P4** Analyzing problems and artifacts	**5.4.1E** **5.4.1K** **5.4.1N**

18. Which of the following is a true statement about data compression?

(A) Data compression is only useful for files being transmitted over the Internet.

(B) Regardless of the compression technique used, once a data file is compressed, it cannot be restored to its original state.

(C) Sending a compressed version of a file ensures that the contents of the file cannot be intercepted by an unauthorized user.

(D) There are trade-offs involved in choosing a compression technique for storing and transmitting data.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
3.3 There are trade-offs when representing information as digital data.	**3.3.1** Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. [P4]	**P4** Analyzing problems and artifacts	**3.3.1C** **3.3.1D** **3.3.1E**

19. An office building has two floors. A computer program is used to control an elevator that travels between the two floors. Physical sensors are used to set the following Boolean variables.

Variable	Description
`onFloor1`	set to `true` if the elevator is stopped on floor 1; otherwise set to `false`
`onFloor2`	set to `true` if the elevator is stopped on floor 2; otherwise set to `false`
`callTo1`	set to `true` if the elevator is called to floor 1; otherwise set to `false`
`callTo2`	set to `true` if the elevator is called to floor 2; otherwise set to `false`

The elevator moves when the door is closed and the elevator is called to the floor that it is not currently on. Which of the following Boolean expressions can be used in a selection statement to cause the elevator to move?

(A) `(onFloor1 AND callTo2) AND (onFloor2 AND callTo1)`

(B) `(onFloor1 AND callTo2) OR (onFloor2 AND callTo1)`

(C) `(onFloor1 OR callTo2) AND (onFloor2 OR callTo1)`

(D) `(onFloor1 OR callTo2) OR (onFloor2 OR callTo1)`

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	**5.5.1** Employ appropriate mathematical and logical concepts in programming. [P4]	**P1** Connecting computing	**5.5.1E** **5.5.1F** **5.5.1G**

20. According to the domain name system (DNS), which of the following is a subdomain of the domain `example.com`?

(A) `about.example.com`

(B) `example.co.uk`

(C) `example.com.org`

(D) `example.org`

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
6.2 Characteristics of the Internet influence the systems built on it.	**6.2.1** Explain characteristics of the Internet and the systems built on it. [P5]	**P5** Communicating	**6.2.1B**

21. Which of the following algorithms require both selection and iteration?

    Select two answers.

    (A) An algorithm that, given two integers, displays the greater of the two integers

    (B) An algorithm that, given a list of integers, displays the number of even integers in the list

    (C) An algorithm that, given a list of integers, displays only the negative integers in the list

    (D) An algorithm that, given a list of integers, displays the sum of the integers in the list

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**4.1.1** Develop an algorithm for implementation in a program. [P2]	**P2** Creating computational artifacts	**4.1.1A** **4.1.1C** **4.1.1D**

22. A teacher uses the following program to adjust student grades on an assignment by adding 5 points to each student's original grade. However, if adding 5 points to a student's original grade causes the grade to exceed 100 points, the student will receive the maximum possible score of 100 points. The students' original grades are stored in the list `gradeList`, which is indexed from 1 to `n`.

```
i ← 1
REPEAT n TIMES
{
   <MISSING CODE>
   i ← i + 1
}
```

SAMPLE EXAM QUESTIONS

The teacher has the following procedures available.

Procedure	**Explanation**
`min (a, b)`	Returns the lesser of the two values `a` and `b`
`max (a, b)`	Returns the greater of the two values `a` and `b`

Which of the following code segments can replace `<MISSING CODE>` so that the program works as intended?

Select <u>two</u> answers.

(A) `gradeList[i] ← min (gradeList[i] + 5, 100)`

(B) `gradeList[i] ← max (gradeList[i] + 5, 100)`

(C)
```
gradeList[i] ← gradeList[i] + 5
IF (gradeList[i] > 100)
{
gradeList[i] ← gradeList[i] - 5
}
```

(D)
```
gradeList[i] ← gradeList[i] + 5
IF (gradeList[i] > 100)
{
gradeList[i] ← 100
}
```

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	**5.5.1** Employ appropriate mathematical and logical concepts in programming. [P1]	**P1** Connecting computing	**5.5.1A** **5.5.1B** **5.5.1H**