

# Practice Exam

## Exam Content and Format

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 12 hours of dedicated class time for students to complete. The end-of-course exam is 2 hours long and includes 70 multiple-choice questions.

## Administering the Practice Exam

This section contains instructions for administering the AP Computer Science Principles Practice Exam. You may wish to use these instructions to create an exam situation that resembles an actual administration. If so, read the indented, boldface directions to the students; all other instructions are for administering the exam and need not be read aloud. Before beginning testing, have all exam materials ready for distribution. These include test booklets and answer sheets. (Reminder: Final instructions for every AP Exam are published in the AP Exam Instructions book.)

When you are ready to begin the exam, say:

**You will be given 2 hours to answer 70 multiple-choice questions. Each question has 4 answer choices.**

- **For question numbers 1 through 62, mark only the single best answer to each question.**
- **For the remaining questions, numbered 131 through 138, mark the two best answer choices for each question.**

**Your total score on this multiple-choice exam is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions. When you do not know the answer to a question, you should eliminate as many choices as you can, and then select the best answer among the remaining choices. If you finish before time is called, you may check your work.**

**Programming reference materials are located at the front of the exam. The reference materials provide instructions and explanations to help you understand the format and meaning of the questions on the test. As you encounter programming questions on the test, you should use the reference materials to clarify the behavior of programming statements found in those questions.**

**You have 2 hours for this exam. Open your exam booklet and begin**

Note Start Time here \_\_\_\_\_. Note Stop Time here \_\_\_\_\_. After 2 hours, say:

**Stop working. The exam is over. I will now collect your exam materials.**

Collect an exam booklet and answer sheet from each student.

Name: \_\_\_\_\_

## AP® Computer Science Principles Answer Sheet

No.	Answer
1	
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131		
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# AP<sup>®</sup> Computer Science Principles Exam

## Multiple Choice

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.**

### At a Glance

**Total Time**

2 hours

**Number of Questions**

70

**Percent of Total Score**

70%

**Writing Instrument**

Pencil required

**Electronic Device**

None allowed

### Instructions

This exam booklet contains 70 multiple-choice questions. Exam reference materials for programming questions are located at the beginning of this booklet. As you encounter programming questions on the exam, you should use the reference materials to clarify the behavior of programming statements found in those questions.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

**For questions 1 through 62,** select the single best answer choice for each question.

**For questions 131 through 138,** select the two best answer choices for each question.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice questions is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

# COMPUTER SCIENCE PRINCIPLES

**Time — 2 hours**

**70 Questions**



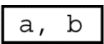
Programming reference materials are included on the following pages. As AP Computer Science Principles does not designate any particular programming language, these reference materials provide instructions and explanations to help you understand the format and meaning of the questions you will see on the exam. The reference materials include two programming formats, text-based and block-based.

Programming instructions use four data types: numbers, Booleans, strings, and lists.

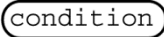
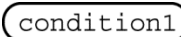
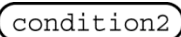
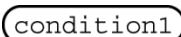
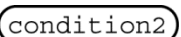
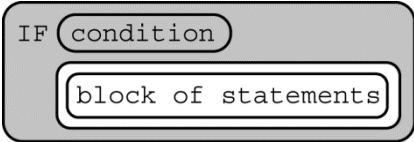
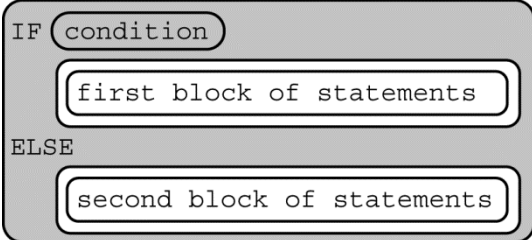
Instructions from any of the following categories may appear on the exam:

- Assignment, Display, and Input
- Arithmetic Operators and Numeric Procedures
- Relational and Boolean Operators
- Selection
- Iteration
- List Operations
- Procedures and Procedure Calls
- Robot

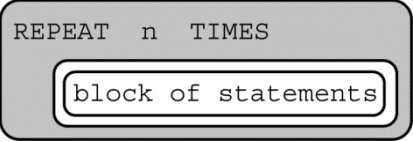

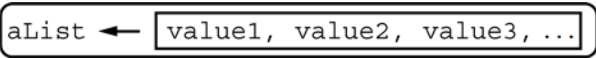
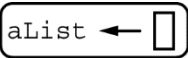
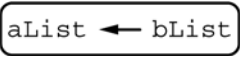
## REFERENCE MATERIALS

Instruction	Explanation
<b>Assignment, Display, and Input</b>	
Text: <code>a ← expression</code>  Block: 	Evaluates <code>expression</code> and then assigns a copy of the result to the variable <code>a</code> .
Text: <code>DISPLAY (expression)</code>  Block: 	Displays the value of <code>expression</code> , followed by a space.
Text: <code>INPUT ()</code>  Block: <code>INPUT</code>	Accepts a value from the user and returns the input value.
<b>Arithmetic Operators and Numeric Procedures</b>	
Text and Block: <code>a + b</code> <code>a - b</code> <code>a * b</code> <code>a / b</code>	<p>The arithmetic operators <code>+</code>, <code>-</code>, <code>*</code>, and <code>/</code> are used to perform arithmetic on <code>a</code> and <code>b</code>.</p> <p>For example, <code>17 / 5</code> evaluates to <code>3.4</code>.</p> <p>The order of operations used in mathematics applies when evaluating expressions.</p>
Text and Block: <code>a MOD b</code>	<p>Evaluates to the remainder when <code>a</code> is divided by <code>b</code>. Assume that <code>a</code> is an integer greater than or equal to <code>0</code> and <code>b</code> is an integer greater than <code>0</code>.</p> <p>For example, <code>17 MOD 5</code> evaluates to <code>2</code>.</p> <p>The <code>MOD</code> operator has the same precedence as the <code>*</code> and <code>/</code> operators.</p>
Text: <code>RANDOM (a, b)</code>  Block: <code>RANDOM</code> 	<p>Generates and returns a random integer from <code>a</code> to <code>b</code>, including <code>a</code> and <code>b</code>. Each result is equally likely to occur.</p> <p>For example, <code>RANDOM (1, 3)</code> could return <code>1</code>, <code>2</code>, or <code>3</code>.</p>
<b>Relational and Boolean Operators</b>	
Text and Block: <code>a = b</code> <code>a ≠ b</code> <code>a &gt; b</code> <code>a &lt; b</code> <code>a ≥ b</code> <code>a ≤ b</code>	<p>The relational operators <code>=</code>, <code>≠</code>, <code>&gt;</code>, <code>&lt;</code>, <code>≥</code>, and <code>≤</code> are used to test the relationship between two variables, expressions, or values. A comparison using relational operators evaluates to a Boolean value.</p> <p>For example, <code>a = b</code> evaluates to <code>true</code> if <code>a</code> and <code>b</code> are equal; otherwise it evaluates to <code>false</code>.</p>


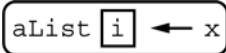
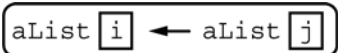




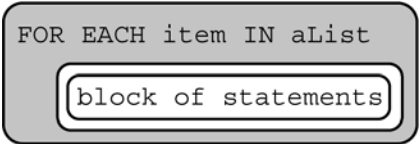
## REFERENCE MATERIALS

Instruction	Explanation
<b>Relational and Boolean Operators (continued)</b>	
<p>Text: NOT condition</p> <p>Block: NOT </p>	Evaluates to true if condition is false; otherwise evaluates to false.
<p>Text: condition1 AND condition2</p> <p>Block:  AND </p>	Evaluates to true if both condition1 and condition2 are true; otherwise evaluates to false.
<p>Text: condition1 OR condition2</p> <p>Block:  OR </p>	Evaluates to true if condition1 is true or if condition2 is true or if both condition1 and condition2 are true; otherwise evaluates to false.
<b>Selection</b>	
<p>Text: IF(condition) {     &lt;block of statements&gt; }</p> <p>Block: </p>	The code in block of statements is executed if the Boolean expression condition evaluates to true; no action is taken if condition evaluates to false.
<p>Text: IF(condition) {     &lt;first block of statements&gt; } ELSE {     &lt;second block of statements&gt; }</p> <p>Block: </p>	The code in first block of statements is executed if the Boolean expression condition evaluates to true; otherwise the code in second block of statements is executed.

## REFERENCE MATERIALS

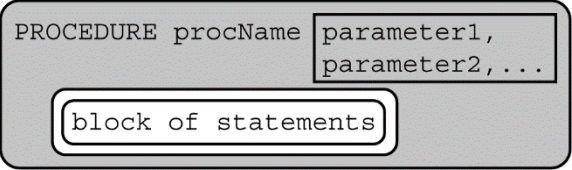
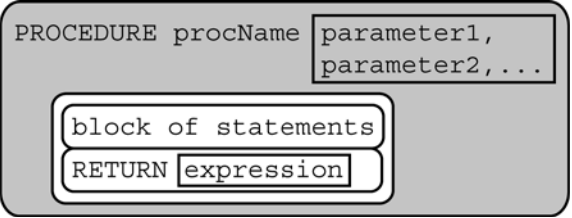

Instruction	Explanation
<b>Iteration</b>	
<p><b>Text:</b>  REPEAT n TIMES  {      &lt;block of statements&gt;  }</p> <p><b>Block:</b></p> 	<p>The code in block of statements is executed n times.</p>
<p><b>Text:</b>  REPEAT UNTIL(condition)  {      &lt;block of statements&gt;  }</p> <p><b>Block:</b></p> 	<p>The code in block of statements is repeated until the Boolean expression condition evaluates to true.</p>
<b>List Operations</b>	
<p>For all list operations, if a list index is less than 1 or greater than the length of the list, an error message is produced and the program terminates.</p>	
<p><b>Text:</b>  aList ← [value1, value2, value3, ...]</p> <p><b>Block:</b></p> 	<p>Creates a new list that contains the values value1, value2, value3, and ... at indices 1, 2, 3, and ... respectively and assigns it to aList.</p>
<p><b>Text:</b>  aList ← []</p> <p><b>Block:</b></p> 	<p>Creates an empty list and assigns it to aList.</p>
<p><b>Text:</b>  aList ← bList</p> <p><b>Block:</b></p> 	<p>Assigns a copy of the list bList to the list aList.</p> <p>For example, if bList contains [20, 40, 60], then aList will also contain [20, 40, 60] after the assignment.</p>
<p><b>Text:</b>  aList[i]</p> <p><b>Block:</b>  aList <span style="border: 1px solid black; padding: 0 2px;">i</span></p>	<p>Accesses the element of aList at index i. The first element of aList is at index 1 and is accessed using the notation aList[1].</p>

## REFERENCE MATERIALS

Instruction	Explanation
List Operations (continued)	
Text: $x \leftarrow \text{aList}[i]$  Block: 	Assigns the value of <code>aList[i]</code> to the variable <code>x</code> .
Text: $\text{aList}[i] \leftarrow x$  Block: 	Assigns the value of <code>x</code> to <code>aList[i]</code> .
Text: $\text{aList}[i] \leftarrow \text{aList}[j]$  Block: 	Assigns the value of <code>aList[j]</code> to <code>aList[i]</code> .
Text: <code>INSERT(aList, i, value)</code>  Block: 	Any values in <code>aList</code> at indices greater than or equal to <code>i</code> are shifted one position to the right. The length of the list is increased by 1, and <code>value</code> is placed at index <code>i</code> in <code>aList</code> .
Text: <code>APPEND(aList, value)</code>  Block: 	The length of <code>aList</code> is increased by 1, and <code>value</code> is placed at the end of <code>aList</code> .
Text: <code>REMOVE(aList, i)</code>  Block: 	Removes the item at index <code>i</code> in <code>aList</code> and shifts to the left any values at indices greater than <code>i</code> . The length of <code>aList</code> is decreased by 1.
Text: <code>LENGTH(aList)</code>  Block: <code>LENGTH</code> 	Evaluates to the number of elements in <code>aList</code> .
Text: <pre>FOR EACH item IN aList {     &lt;block of statements&gt; }</pre> Block: 	The variable <code>item</code> is assigned the value of each element of <code>aList</code> sequentially, in order, from the first element to the last element. The code in block of statements is executed once for each assignment of <code>item</code> .



## REFERENCE MATERIALS

Instruction	Explanation
<b>Procedures and Procedure Calls</b>	
<p><b>Text:</b>  <pre>PROCEDURE procName(parameter1,                     parameter2, ...)</pre> <pre>{     &lt;block of statements&gt; }</pre></p> <p><b>Block:</b></p> 	<p>Defines <code>procName</code> as a procedure that takes zero or more arguments. The procedure contains block of statements.</p> <p>The procedure <code>procName</code> can be called using the following notation, where <code>arg1</code> is assigned to <code>parameter1</code>, <code>arg2</code> is assigned to <code>parameter2</code>, etc.:  <code>procName(arg1, arg2, ...)</code></p>
<p><b>Text:</b>  <pre>PROCEDURE procName(parameter1,                     parameter2, ...)</pre> <pre>{     &lt;block of statements&gt;     RETURN(expression) }</pre></p> <p><b>Block:</b></p> 	<p>Defines <code>procName</code> as a procedure that takes zero or more arguments. The procedure contains block of statements and returns the value of expression. The <code>RETURN</code> statement may appear at any point inside the procedure and causes an immediate return from the procedure back to the calling statement.</p> <p>The value returned by the procedure <code>procName</code> can be assigned to the variable <code>result</code> using the following notation:  <code>result ← procName(arg1, arg2, ...)</code></p>
<p><b>Text:</b>  <pre>RETURN(expression)</pre></p> <p><b>Block:</b></p> 	<p>Returns the flow of control to the point where the procedure was called and returns the value of expression.</p>

## REFERENCE MATERIALS

Instruction	Explanation
<b>Robot</b>	
If the robot attempts to move to a square that is not open or is beyond the edge of the grid, the robot will stay in its current location and the program will terminate.	
Text: <code>MOVE_FORWARD()</code>  Block: <div style="border: 1px solid black; border-radius: 10px; padding: 2px 10px; display: inline-block;">MOVE_FORWARD</div>	The robot moves one square forward in the direction it is facing.
Text: <code>ROTATE_LEFT()</code>  Block: <div style="border: 1px solid black; border-radius: 10px; padding: 2px 10px; display: inline-block;">ROTATE_LEFT</div>	The robot rotates in place 90 degrees counterclockwise (i.e., makes an in-place left turn).
Text: <code>ROTATE_RIGHT()</code>  Block: <div style="border: 1px solid black; border-radius: 10px; padding: 2px 10px; display: inline-block;">ROTATE_RIGHT</div>	The robot rotates in place 90 degrees clockwise (i.e., makes an in-place right turn).
Text: <code>CAN_MOVE(direction)</code>  Block: <code>CAN_MOVE</code> <div style="border: 1px solid black; padding: 2px 10px; display: inline-block;">direction</div>	Evaluates to <code>true</code> if there is an open square one square in the direction relative to where the robot is facing; otherwise evaluates to <code>false</code> . The value of <code>direction</code> can be <code>left</code> , <code>right</code> , <code>forward</code> , or <code>backward</code> .

**Directions:** Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then enter the letter in the corresponding space on the answer sheet.

1. Which of the following is an example of a phishing attack?
  - (A) Loading malicious software onto a user's computer in order to secretly gain access to sensitive information
  - (B) Flooding a user's computer with e-mail requests in order to cause the computer to crash
  - (C) Gaining remote access to a user's computer in order to steal user IDs and passwords
  - (D) Using fraudulent e-mails in order to trick a user into voluntarily providing sensitive information

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2. To be eligible for a particular ride at an amusement park, a person must be at least 12 years old and must be between 50 and 80 inches tall, inclusive.

Let `age` represent a person's age, in years, and let `height` represent the person's height, in inches. Which of the following expressions evaluates to `true` if and only if the person is eligible for the ride?

- (A) `(age ≥ 12) AND ((height ≥ 50) AND (height ≤ 80))`
- (B) `(age ≥ 12) AND ((height ≤ 50) AND (height ≥ 80))`
- (C) `(age ≥ 12) AND ((height ≤ 50) OR (height ≥ 80))`
- (D) `(age ≥ 12) OR ((height ≥ 50) AND (height ≤ 80))`

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**GO ON TO THE NEXT PAGE.**

3. Consider the following code segment.

<code>first ← 100</code>
<code>second ← 200</code>
<code>temp ← first</code>
<code>second ← temp</code>
<code>first ← second</code>

What are the values of `first` and `second` as a result of executing the code segment?

- (A) `first` = 100, `second` = 100
  - (B) `first` = 100, `second` = 200
  - (C) `first` = 200, `second` = 100
  - (D) `first` = 200, `second` = 200
- 
4. Which of the following best explains the relationship between the Internet and the World Wide Web?
- (A) Both the Internet and the World Wide Web refer to the same interconnected network of devices.
  - (B) The Internet is an interconnected network of data servers, and the World Wide Web is a network of user devices that communicates with the data servers.
  - (C) The Internet is a local network of interconnected devices, and the World Wide Web is a global network that connects the local networks with each other.
  - (D) The Internet is a network of interconnected networks, and the World Wide Web is a system of linked pages, programs, and files that is accessed via the Internet.

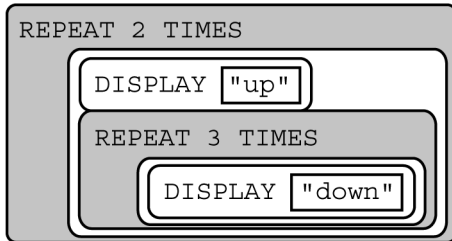
**GO ON TO THE NEXT PAGE.**

5. A code segment is intended to display the following output.

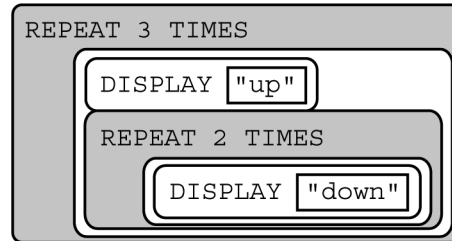
up down down down up down down down

Which of the following code segments can be used to display the intended output?

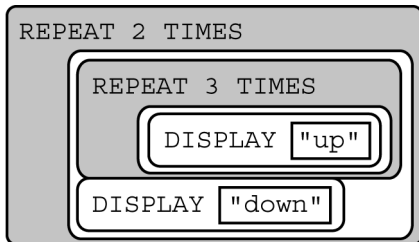
(A)



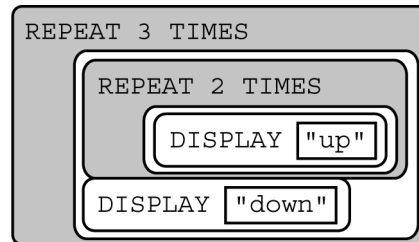
(B)



(C)



(D)



**GO ON TO THE NEXT PAGE.**

6. Which of the following best exemplifies the use of multifactor authentication to protect an online banking system?
- (A) When a user resets a password for an online bank account, the user is required to enter the new password twice.
  - (B) When multiple people have a shared online bank account, they are each required to have their own unique username and password.
  - (C) After entering a password for an online bank account, a user must also enter a code that is sent to the user's phone via text message.
  - (D) An online bank requires users to change their account passwords multiple times per year without using the same password twice.

**GO ON TO THE NEXT PAGE.**

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7. A game is played by moving a game piece left or right along a horizontal game board. The board consists of spaces of various colors, as shown. The circle represents the initial location of the game piece.

Yellow	Black	Green	Green	Red	Yellow	Black	Black	Yellow	Black
									●

The following algorithm indicates how the game is played. The game continues until the game is either won by landing on the red space or lost when the piece moves off either end of the board.

Step 1: Place a game piece on a space that is not red and set a counter to 0.

Step 2: If the game piece is on a yellow space, move the game piece 3 positions to the left and go to step 3. Otherwise, if the game piece is on a black space, move the game piece 1 position to the left and go to step 3. Otherwise, if the game piece is on a green space, move the game piece 2 positions to the right and go to step 3.

Step 3: Increase the value of the counter by 1.

Step 4: If game piece is on the red space or moved off the end of the game board, the game is complete. Otherwise, go back to step 2.

If a game is begun by placing the game piece on the rightmost black space for step 1, what will be the value of the counter at the end of the game?

- (A) 2
- (B) 3
- (C) 4
- (D) 5

**GO ON TO THE NEXT PAGE.**

8. Which of the following best describes a direct benefit in using redundant routing on the Internet?
- (A) Redundancy enables messages to be transmitted with as few packets as possible.
  - (B) Redundancy enables network devices to communicate with as few network connections as possible.
  - (C) Redundancy often allows messages to be sent on the network even if some network devices or connections have failed.
  - (D) Redundancy prevents network communications from being intercepted by unauthorized individuals.

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9. Which of the following best explains how an analog audio signal is typically represented by a computer?
- (A) An analog audio signal is measured as input parameters to a program or procedure. The inputs are represented at the lowest level as a collection of variables.
  - (B) An analog audio signal is measured at regular intervals. Each measurement is stored as a sample, which is represented at the lowest level as a sequence of bits.
  - (C) An analog audio signal is measured as a sequence of operations that describe how the sound can be reproduced. The operations are represented at the lowest level as programming instructions.
  - (D) An analog audio signal is measured as text that describes the attributes of the sound. The text is represented at the lowest level as a string.

**GO ON TO THE NEXT PAGE.**



**Questions 10–11 refer to the information below.**

The player controls in a particular video game are represented by numbers. The controls and their corresponding binary values are shown in the following table.

Control	Binary Value
←	01000
↑	01001
→	01011
↓	01111
Jump	11000
Run	11001
Pause	11011
Reset	11111

The numeric values for the controls can also be represented in decimal (base 10).

10. What is the decimal value for the jump control?

- (A) 3
- (B) 12
- (C) 24
- (D) 48

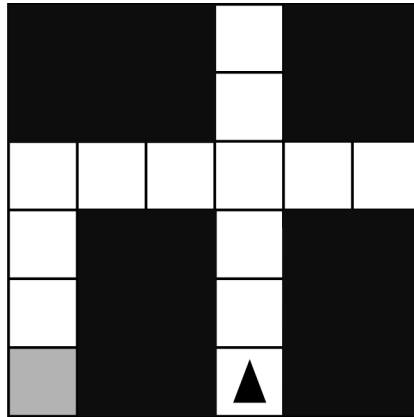
---

11. What control is represented by the decimal value 15 ?

- (A) ←
- (B) ↑
- (C) →
- (D) ↓

**GO ON TO THE NEXT PAGE.**

12. The grid below contains a robot represented as a triangle, initially facing toward the top of the grid. The robot can move into a white or gray square but cannot move into a black region.



The code segment below uses the procedure `goalReached`, which evaluates to `true` if the robot is in the gray square and evaluates to `false` otherwise.

```
REPEAT UNTIL (goalReached())
{
    <MISSING CODE>
}
```

Which of the following replacements for `<MISSING CODE>` can be used to move the robot to the gray square?

- (A) 

```
IF (CAN_MOVE(left))
{
    ROTATE_LEFT()
    MOVE_FORWARD()
}
```
- (B) 

```
IF (CAN_MOVE(forward))
{
    MOVE_FORWARD()
    ROTATE_LEFT()
}
```
- (C) 

```
IF (CAN_MOVE(left))
{
    ROTATE_LEFT()
}
MOVE_FORWARD()
```
- (D) 

```
IF (CAN_MOVE(forward))
{
    MOVE_FORWARD()
}
ELSE
{
    ROTATE_LEFT()
}
```

**GO ON TO THE NEXT PAGE.**

13. Which of the following is NOT a benefit of collaborating to develop a computing innovation?
- (A) Collaboration can decrease the size and complexity of tasks required of individual team members.
  - (B) Collaboration can make it easier to find and correct errors during the development process.
  - (C) Collaboration eliminates the need to resolve differences of opinion.
  - (D) Collaboration facilitates multiple perspectives in developing ideas.

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14. A list of numbers is considered increasing if each value after the first is greater than or equal to the preceding value. The following procedure is intended to return `true` if `numberList` is increasing and return `false` otherwise. Assume that `numberList` contains at least two elements.

```
Line 1:  PROCEDURE isIncreasing(numberList)
Line 2:  {
Line 3:      count ← 2
Line 4:      REPEAT UNTIL(count > LENGTH(numberList))
Line 5:      {
Line 6:          IF(numberList[count] < numberList[count - 1])
Line 7:              {
Line 8:                  RETURN(true)
Line 9:              }
Line 10:         count ← count + 1
Line 11:     }
Line 12:     RETURN(false)
Line 13: }
```

Which of the following changes is needed for the program to work as intended?

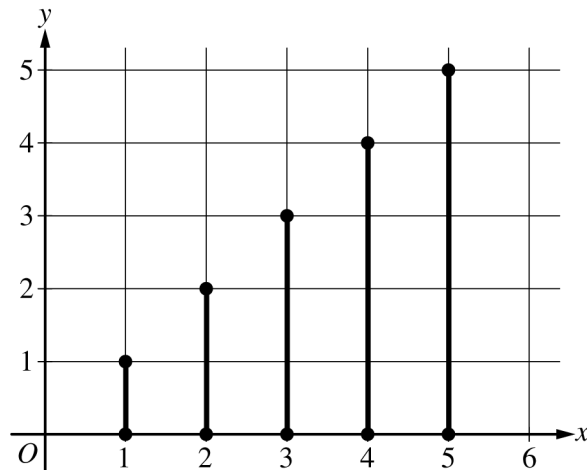
- (A) In line 3, 2 should be changed to 1.
- (B) In line 6, < should be changed to  $\geq$ .
- (C) Lines 8 and 12 should be interchanged.
- (D) Lines 10 and 11 should be interchanged.

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15. Consider the following procedure.

Procedure Call	Explanation
<code>drawLine(x1, y1, x2, y2)</code>	Draws a line segment on a coordinate grid with endpoints at coordinates $(x1, y1)$ and $(x2, y2)$

The `drawLine` procedure is to be used to draw the following figure on a coordinate grid.



Which of the following code segments can be used to draw the figure?

- (A) `xVal  $\leftarrow$  1`  
`yVal  $\leftarrow$  0`  
`len  $\leftarrow$  1`  
`REPEAT 5 TIMES`  
`{`  
`drawLine(xVal, yVal, xVal, yVal + len)`  
`xVal  $\leftarrow$  xVal + 1`  
`len  $\leftarrow$  len + 1`  
`}`
- (B) `xVal  $\leftarrow$  1`  
`yVal  $\leftarrow$  0`  
`len  $\leftarrow$  1`  
`REPEAT 5 TIMES`  
`{`  
`drawLine(xVal, yVal, xVal + len, yVal)`  
`yVal  $\leftarrow$  yVal + 1`  
`len  $\leftarrow$  len + 1`  
`}`

**GO ON TO THE NEXT PAGE.**

(C) xVal  $\leftarrow$  5  
yVal  $\leftarrow$  0  
len  $\leftarrow$  5  
REPEAT 5 TIMES  
{  
    drawLine(xVal, yVal, xVal, yVal + len)  
    xVal  $\leftarrow$  xVal - 1  
}

(D) xVal  $\leftarrow$  5  
yVal  $\leftarrow$  0  
len  $\leftarrow$  5  
REPEAT 5 TIMES  
{  
    drawLine(xVal, yVal, xVal + len, yVal)  
    yVal  $\leftarrow$  yVal - 1  
    len  $\leftarrow$  len - 1  
}

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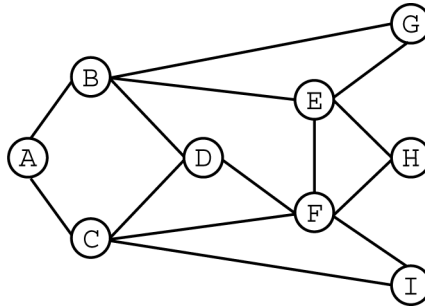
16. The author of an e-book publishes the e-book using a no-rights-reserved Creative Commons license. Which of the following best explains the consequences of publishing the book with this type of license?
- (A) The contents of the e-book will be encrypted and can only be decrypted by authorized individuals.
  - (B) Individuals can freely distribute or use the contents of the e-book without needing to obtain additional permissions from the author.
  - (C) Individuals will be legally prevented from sharing the e-book on a peer-to-peer network.
  - (D) Individuals will be legally prevented from using excerpts from the e-book in another published work.

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**Questions 17–18 refer to the information below.**

The figure below represents a network of physically linked devices labeled A through I. A line between two devices indicates that the devices can communicate directly with each other.

Any information sent between two devices that are not directly connected must go through at least one other device. For example, in the network represented below, information can be sent directly between A and B, but information sent between devices A and G must go through other devices.



17. What is the minimum number of connections that must be broken or removed before device B can no longer communicate with device C?

(A) Three  
(B) Four  
(C) Five  
(D) Six

- 
18. Which of the following statements is true about the network?

(A) Information sent from device A to device D can use at most two unique paths.  
(B) Information sent from device A to device I will pass through at most four other devices.  
(C) If devices B and F fail, then device A will not be able to communicate with device G.  
(D) If devices C and F fail, then device D will not be able to communicate with device H.

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19. Which of the following best explains how devices and information can be susceptible to unauthorized access if weak passwords are used?
- (A) Unauthorized individuals can deny service to a computing system by overwhelming the system with login attempts.
  - (B) Unauthorized individuals can exploit vulnerabilities in compression algorithms to determine a user's password from their decompressed data.
  - (C) Unauthorized individuals can exploit vulnerabilities in encryption algorithms to determine a user's password from their encryption key.
  - (D) Unauthorized individuals can use data mining and other techniques to guess a user's password.

- 
20. A local router is configured to limit the bandwidth of guest users connecting to the Internet. Which of the following best explains the result of this configuration as compared to a configuration in which the router does not limit the bandwidth?
- (A) The amount of time it takes guest users to send and receive large files is likely to decrease.
  - (B) The number of packets required for guest users to send and receive data is likely to decrease.
  - (C) Guest users will be prevented from having fault-tolerant routing on the Internet.
  - (D) Guest users will be restricted in the maximum amount of data that they can send and receive per second.

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21. A video-streaming Web site keeps count of the number of times each video has been played since it was first added to the site. The count is updated each time a video is played and is displayed next to each video to show its popularity.

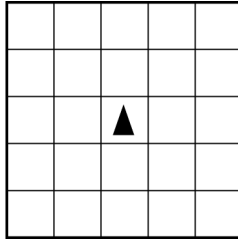
At one time, the count for the most popular video was about two million. Sometime later, the same video displayed a seven-digit negative number as its count, while the counts for the other videos displayed correctly. Which of the following is the most likely explanation for the error?

- (A) The count for the video became larger than the maximum value allowed by the data type used to store the count.
- (B) The mathematical operations used to calculate the count caused a rounding error to occur.
- (C) The software used to update the count failed when too many videos were played simultaneously by too many users.
- (D) The software used to update the count contained a sampling error when using digital data to approximate the analog count.

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22. The question below uses a robot in a grid of squares. The robot is represented as a triangle, which is initially in the center square and facing toward the top of the grid.



The following code segment is used to move the robot in the grid.

```
count ← 1
REPEAT 4 TIMES
{
    REPEAT count TIMES
    {
        MOVE_FORWARD()
    }
    ROTATE_LEFT()
    count ← count + 1
}
```

Which of the following code segments will move the robot from the center square along the same path as the code segment above?

(A) 

```
count ← 0
REPEAT 4 TIMES
{
    count ← count + 1
    REPEAT count TIMES
    {
        MOVE_FORWARD()
    }
    ROTATE_LEFT()
}
```

(B) 

```
count ← 0
REPEAT 4 TIMES
{
    count ← count + 1
    ROTATE_LEFT()
    REPEAT count TIMES
    {
        MOVE_FORWARD()
    }
}
```

(C) 

```
count ← 0
REPEAT 4 TIMES
{
    REPEAT count TIMES
    {
        ROTATE_LEFT()
    }
    MOVE_FORWARD()
    count ← count + 1
}
```

(D) 

```
count ← 0
REPEAT 4 TIMES
{
    ROTATE_LEFT()
    REPEAT count TIMES
    {
        MOVE_FORWARD()
    }
    count ← count + 1
}
```

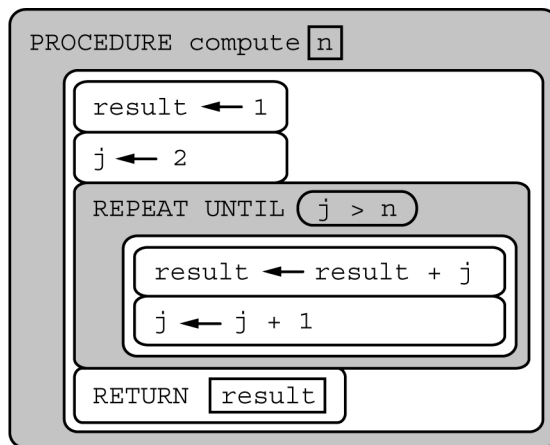
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23. Which of the following statements about the Internet is true?
- (A) The Internet is a computer network that uses proprietary communication protocols.
  - (B) The Internet is designed to scale to support an increasing number of users.
  - (C) The Internet requires all communications to use encryption protocols.
  - (D) The Internet uses a centralized system to determine how packets are routed.
- 
24. In which of the following situations would it be most appropriate to choose lossy compression over lossless compression?
- (A) Storing digital photographs to be printed and displayed in a large format in an art gallery
  - (B) Storing a formatted text document to be restored to its original version for a print publication
  - (C) Storing music files on a smartphone in order to maximize the number of songs that can be stored
  - (D) Storing a video file on an external device in order to preserve the highest possible video quality

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25. In the following procedure, the parameter  $n$  is an integer greater than 2.



Which of the following best describes the value returned by the procedure?

- (A) The procedure returns nothing because it will not terminate.
  - (B) The procedure returns the value of  $2 * n$ .
  - (C) The procedure returns the value of  $n * n$ .
  - (D) The procedure returns the sum of the integers from 1 to  $n$ .
- 
26. Which of the following best describes a challenge involved in using a parallel computing solution?
- (A) A parallel computing solution may not be appropriate for an algorithm in which each step requires the output from the preceding step.
  - (B) A parallel computing solution may not be appropriate for an algorithm in which the same formula is applied to many numeric data elements.
  - (C) A parallel computing solution may not be appropriate for an algorithm that can be easily broken down into small independent tasks.
  - (D) A parallel computing solution may not be appropriate for an algorithm that searches for occurrences of a key word in a large number of documents.

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27. A certain social media application is popular with people across the United States. The developers of the application are updating the algorithm used by the application to introduce a new feature that allows users of the application with similar interests to connect with one another. Which of the following strategies is LEAST likely to introduce bias into the application?
- (A) Enticing users to spend more time using the application by providing the updated algorithm for users who use the application at least ten hours per week
  - (B) Inviting a random sample of all users to try out the new algorithm and provide feedback before it is released to a wider audience
  - (C) Providing the updated algorithm only to teenage users to generate excitement about the new feature
  - (D) Testing the updated algorithm with a small number of users in the city where the developers are located so that immediate feedback can be gathered

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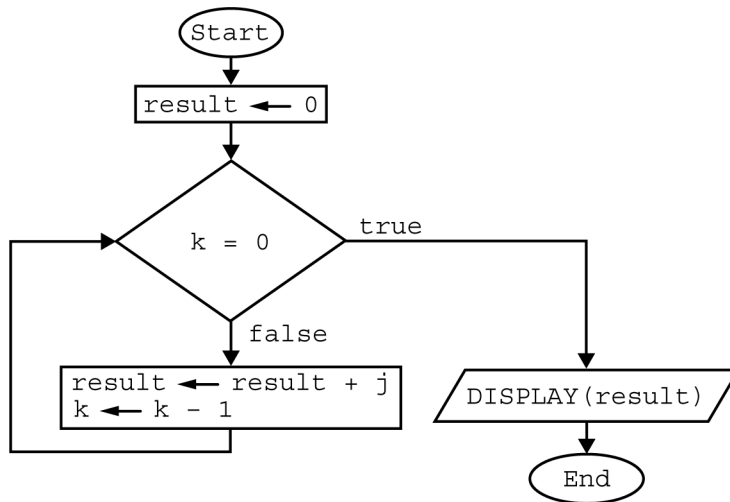
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Questions 28–29 refer to the information below.

A flowchart provides a way to visually represent an algorithm and uses the following building blocks.

Block	Explanation
Oval	The start or end of the algorithm
Rectangle	One or more processing steps, such as a statement that assigns a value to a variable
Diamond	A conditional or decision step, where execution proceeds to the side labeled <code>true</code> if the condition is true and to the side labeled <code>false</code> otherwise
Parallelogram	Displays a message

In the flowchart below, assume that  $j$  and  $k$  are assigned integer values.



28. Which of the following initial values of  $j$  and  $k$  will cause the algorithm represented in the flowchart to result in an infinite loop?

- (A)  $j = -5$ ,  $k = 5$
- (B)  $j = 0$ ,  $k = 5$
- (C)  $j = 5$ ,  $k = 0$
- (D)  $j = 5$ ,  $k = -5$

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29. Based on the algorithm represented in the flowchart, what value is displayed if  $j$  has the initial value 3 and  $k$  has the initial value 4 ?
- (A) 7
  - (B) 9
  - (C) 10
  - (D) 12

---

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30. Which of the following best explains how data is transmitted on the Internet?
- (A) Data is broken into packets, which are all sent to the recipient in a specified order along the same path.
  - (B) Data is broken into packets, which can be sent along different paths.
  - (C) All data is transmitted in a single packet through a direct connection between the sender and the recipient.
  - (D) Multiple data files are bundled together in a packet and transmitted together.

- 
31. A binary number is to be transformed by appending three 0s to the end of the number. For example, 11101 is transformed to 11101000. Which of the following correctly describes the relationship between the transformed number and the original number?
- (A) The transformed number is 3 times the value of the original number.
  - (B) The transformed number is 4 times the value of the original number.
  - (C) The transformed number is 8 times the value of the original number.
  - (D) The transformed number is 1,000 times the value of the original number.

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32. Which of the following is a true statement about the use of public key encryption in transmitting messages?
- (A) Public key encryption enables parties to initiate secure communications through an open medium, such as the Internet, in which there might be eavesdroppers.
  - (B) Public key encryption is not considered a secure method of communication because a public key can be intercepted.
  - (C) Public key encryption only allows the encryption of documents containing text; documents containing audio and video must use a different encryption method.
  - (D) Public key encryption uses a single key that should be kept secure because it is used for both encryption and decryption.

- 
33. A company delivers packages by truck and would like to minimize the length of the route that each driver must travel in order to reach  $n$  delivery locations. The company is considering two different algorithms for determining delivery routes.

Algorithm I: Generate all possible routes, compute their lengths, and then select the shortest possible route. This algorithm does not run in reasonable time.

Algorithm II: Starting from an arbitrary delivery location, find the nearest unvisited delivery location. Continue creating the route by selecting the nearest unvisited location until all locations have been visited. This algorithm does not guarantee the shortest possible route and runs in time proportional to  $n^2$ .

Which of the following best categorizes algorithm II?

- (A) Algorithm II attempts to use an algorithmic approach to solve an otherwise undecidable problem.
- (B) Algorithm II uses a heuristic approach to provide an approximate solution in reasonable time.
- (C) Algorithm II provides no improvement over algorithm I because neither algorithm runs in reasonable time.
- (D) Algorithm II requires a much faster computer in order to provide any improvement over algorithm I.

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34. In a science experiment, result X is expected to occur 25% of the time and result Y is expected to occur the remaining 75% of the time. The following code segment is intended to simulate the experiment if there are 100 trials.

```
Line 1:  xCount ← 0
Line 2:  yCount ← 0
Line 3:  REPEAT 100 TIMES
Line 4:  {
Line 5:      IF (RANDOM(1, 4) = 1)
Line 6:      {
Line 7:          xCount ← xCount + 1
Line 8:      }
Line 9:      IF (RANDOM(1, 4) > 1)
Line 10:     {
Line 11:         yCount ← yCount + 1
Line 12:     }
Line 13: }
Line 14: DISPLAY("Result X occurred")
Line 15: DISPLAY(xCount)
Line 16: DISPLAY("times and result Y occurred")
Line 17: DISPLAY(yCount)
Line 18: DISPLAY("times.")
```

A programmer runs the code segment, and the following message is displayed.

Result X occurred 24 times and result Y occurred 70 times.

The result shows that 94 trials were counted, rather than the intended 100 trials. Which of the following changes to the code segment will ensure a correct simulation of the experiment?

- (A) Replacing line 9 with `IF (RANDOM(1, 4) ≥ 2)`
- (B) Replacing line 9 with `ELSE`
- (C) Interchanging lines 5 and 9
- (D) Interchanging lines 7 and 11

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35. A city maintains a database of all traffic tickets that were issued over the past ten years. The tickets are divided into the following two categories.

- Moving violations
- Nonmoving violations

The data recorded for each ticket include only the following information.

- The month and year in which the ticket was issued
- The category of the ticket

Which of the following questions CANNOT be answered using only the information in the database?

- (A) Have the total number of traffic tickets per year increased each year over the past ten years?
- (B) In the past ten years, were nonmoving violations more likely to occur on a weekend than on a weekday?
- (C) In the past ten years, were there any months when moving violations occurred more often than nonmoving violations?
- (D) In how many of the past ten years were there more than one million moving violations?

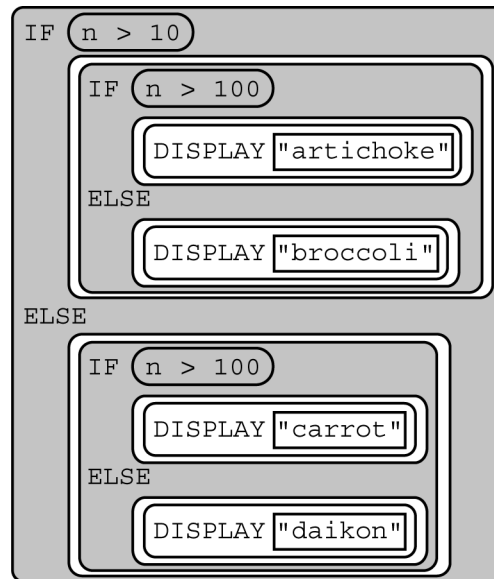
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36. Individuals sometimes attempt to remove personal information from the Internet. Which of the following is the LEAST likely reason the personal information is hard to remove?

- (A) Internet users with a copy of the information might redistribute the personal information without first seeking permission.
- (B) There are potentially an extremely large number of devices on the Internet that may contain the information.
- (C) Automated technologies collect information about Internet users without their knowledge.
- (D) All personal information is stored online using authentication measures, making the information hard to access.

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37. In the following code segment, assume that the variable `n` has been initialized with an integer value.



Which of the following is NOT a possible value displayed by the program?

- (A) "artichoke"
- (B) "broccoli"
- (C) "carrot"
- (D) "daikon"

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38. A scientist wants to investigate several problems. In which of the following situations is using a simulation LEAST suitable for solving a problem?
- (A) When a scientific study requires performing a large number of trials that need to be conducted very quickly
  - (B) When it is considered acceptable to make simplifying assumptions when modeling a real-world object or phenomenon
  - (C) When performing an experiment that would be too costly or dangerous to conduct in the real world
  - (D) When the solution to the problem requires real-world data inputs that are continually measured at regular intervals.

- 
39. A store uses binary numbers to assign a unique binary sequence to each item in its inventory. What is the minimum number of bits required for each binary sequence if the store has between 75 and 100 items in its inventory?
- (A) 5
  - (B) 6
  - (C) 7
  - (D) 8

---

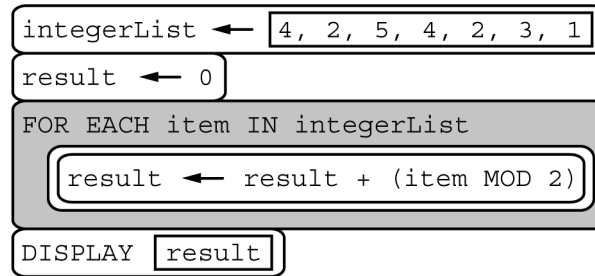
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40. A state government is attempting to reduce the digital divide. Which of the following activities has the greatest potential to contribute to the digital divide rather than reducing it?
- (A) Providing programs that focus on technology literacy at local libraries
  - (B) Requiring applicants for government jobs to apply using an online platform
  - (C) Working with technology companies to offer computing devices at discounted prices to individuals with reduced incomes
  - (D) Working with telecommunications companies to build network infrastructure in remote areas

- 
41. An online gaming company is introducing several new initiatives to encourage respectful communication between players of online games. Which of the following best describes a solution that uses crowdsourcing?
- (A) The company allows individual players to endorse fellow players based on courteous interactions. Once a player receives enough endorsements, the player is given free rewards that can be used during gameplay.
  - (B) The company eliminates chat from gameplay and sets the default chat policy to off. Players must actively turn on chat to converse outside of gameplay.
  - (C) The company introduces software that monitors all chats. Inappropriate conversations are identified, and players involved in the conversations are banned from the game.
  - (D) The company updates the acceptable content guidelines to explicitly describe appropriate and inappropriate behavior. All players must electronically sign an agreement to adhere to the guidelines.

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42. Consider the following code segment.



What value is displayed as a result of executing the code segment?

- (A) 3
- (B) 4
- (C) 9
- (D) 12

---

43. Which of the following best exemplifies the use of keylogging to gain unauthorized access to a computer system?

- (A) A user unintentionally installs a program on their computer that records all user input and forwards it to another computer. A few weeks later, someone else is able to access the user's computer using the recorded data.
- (B) A user has a very common password for an online banking account. Someone else guesses the password after a few attempts and gains access to the user's account.
- (C) A user logs into an unsecure Web site. Someone else is able to view unencrypted log-in information as it is transmitted over the Internet. The user has the same username and password for multiple accounts, so the user's log-in information for multiple systems may be compromised.
- (D) A user receives an e-mail that claims to be from the user's bank. The e-mail instructs the user to click on a link to a Web site and enter a username and password to verify an account. Shortly after following the steps, the user discovers that the Web site is fraudulent and that the user's username and password were stolen.

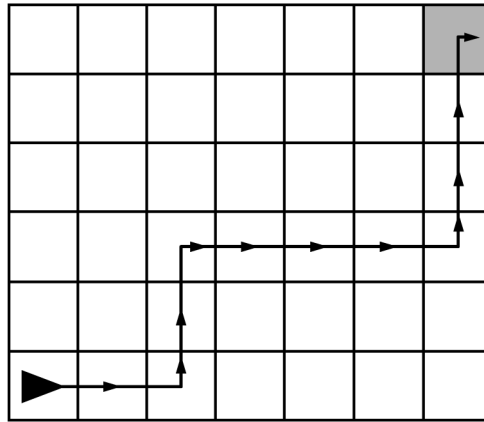
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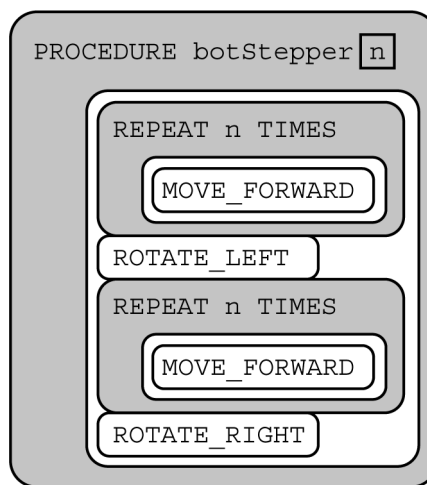
44. A program developed for a Web store represents customer account balances using a format that approximates real numbers. While testing the program, a software developer discovers that some values appear to be mathematically imprecise. Which of the following is the most likely cause of the imprecision?
- (A) The account balances are represented using a fixed number of bits, resulting in overflow errors.
  - (B) The account balances are represented using a fixed number of bits, resulting in round-off errors.
  - (C) The account balances are represented using an unlimited number of bits, resulting in overflow errors.
  - (D) The account balances are represented using an unlimited number of bits, resulting in round-off errors.

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45. The following question uses a robot in a grid of squares. The robot is represented by a triangle, which is initially facing right.



Consider the following procedure.



Which of the following code segments will move the robot to the gray square along the path indicated by the arrows?

- (A) `botStepper 2`  
`botStepper 3`
- (B) `botStepper 3`  
`botStepper 4`
- (C) `botStepper 2`  
`MOVE_FORWARD`  
`botStepper 3`
- (D) `botStepper 3`  
`MOVE_FORWARD`  
`botStepper 4`

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Questions 46–47 refer to the information below.

A large spreadsheet contains the following information about local restaurants. A sample portion of the spreadsheet is shown below.

	<b>A</b> <b>Restaurant Name</b>	<b>B</b> <b>Price Range</b>	<b>C</b> <b>Number of Customer Ratings</b>	<b>D</b> <b>Average Customer Rating</b>	<b>E</b> <b>Accepts Credit Cards</b>
<b>1</b>	Joey Calzone's Pizzeria	lo	182	3.5	false
<b>2</b>	78th Street Bistro	med	41	4.5	false
<b>3</b>	Seaside Taqueria	med	214	4.5	true
<b>4</b>	Delicious Sub Shop II	lo	202	4.0	false
<b>5</b>	Rustic Farm Tavern	hi	116	4.5	true
<b>6</b>	ABC Downtown Diner	med	0	-1.0	true

- In column B, the price range represents the typical cost of a meal, where "lo" indicates under \$10, "med" indicates \$11 to \$30, and "hi" indicates over \$30.
- In column D, the average customer rating is set to -1.0 for restaurants that have no customer ratings.

46. A student is developing an algorithm to determine which of the restaurants that accept credit cards has the greatest average customer rating. Restaurants that have not yet received any customer ratings and restaurants that do not accept credit card are to be ignored.

Once the algorithm is complete, the desired restaurant will appear in the first row of the spreadsheet. If there are multiple entries that fit the desired criteria, it does not matter which of them appears in the first row.

The student has the following actions available but is not sure of the order in which they should be executed.

<b>Action</b>	<b>Explanation</b>
Filter by number of ratings	Remove entries for restaurants with no customer ratings
Filter by payment type	Remove entries for restaurants that do not accept credit cards
Sort by rating	Sort the rows in the spreadsheet on column D from greatest to least

Assume that applying either of the filters will not change the relative order of the rows remaining in the spreadsheet.

Which of the following sequences of steps can be used to identify the desired restaurant?

- I. Filter by number of ratings, then filter by payment type, then sort by rating
  - II. Filter by number of ratings, then sort by rating, then filter by payment type
  - III. Sort by rating, then filter by number of ratings, then filter by payment type
- (A) I and II only  
 (B) I and III only  
 (C) II and III only  
 (D) I, II, and III

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47. A student wants to count the number of restaurants in the spreadsheet whose price range is \$30 or less and whose average customer rating is at least 4.0. For a given row in the spreadsheet, suppose `prcRange` contains the price range as a string and `avgRating` contains the average customer rating as a decimal number.

Which of the following expressions will evaluate to `true` if the restaurant should be counted and evaluates to `false` otherwise?

- (A) `(avgRating ≥ 4.0) AND ((prcRange = "lo") AND (prcRange = "med"))`
- (B) `(avgRating ≥ 4.0) AND ((prcRange = "lo") OR (prcRange = "med"))`
- (C) `(avgRating ≥ 4.0) OR ((prcRange = "lo") AND (prcRange = "med"))`
- (D) `(avgRating ≥ 4.0) OR ((prcRange = "lo") OR (prcRange = "med"))`

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48. Which of the following is an example of an attack using a rogue access point?
- (A) An unauthorized individual gains the ability to view network traffic by connecting to a network router that uses weak or no security measures.
  - (B) An unauthorized individual physically disconnects an exposed network router, making the network unavailable to some users.
  - (C) An unauthorized individual poses as a network administrator and attempts to trick a user into providing personal information.
  - (D) A group of unauthorized individuals overwhelms a network router with traffic, making it unavailable to some users.

- 
49. Which of the following best explains the ability to solve problems algorithmically?
- (A) Any problem can be solved algorithmically, though some algorithmic solutions may require humans to validate the results.
  - (B) Any problem can be solved algorithmically, though some algorithmic solutions must be executed on multiple devices in parallel.
  - (C) Any problem can be solved algorithmically, though some algorithmic solutions require a very large amount of data storage to execute.
  - (D) There exist some problems that cannot be solved algorithmically using any computer.

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50. Which of the following best explains how symmetric encryption algorithms are typically used?
- (A) Symmetric encryption uses a single key that should be kept secret. The same key is used for both encryption and decryption of data.
  - (B) Symmetric encryption uses a single key that should be made public. The same key is used for both encryption and decryption of data.
  - (C) Symmetric encryption uses two keys that should both be kept secret. One key is used for encryption, and the other is used for decryption.
  - (D) Symmetric encryption uses two keys. The key used for encryption should be made public, but the key used for decryption should be kept secret.

- 
51. Which of the following research proposals is most likely to be successful as a citizen science project?
- (A) Collecting pictures of birds from around the world that can then be analyzed to determine how location affects bird size
  - (B) Monitoring a group of cells in a laboratory to determine how growth rate is affected by exposure to varying temperatures
  - (C) Using a simulation to determine which one from a set of chemicals causes the most significant change to local animal and plant life
  - (D) Using specialized equipment to perform three-dimensional scans of complex proteins found in human cells

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52. A sorted list of numbers contains 128 elements. Which of the following is closest to the maximum number of list elements that can be examined when performing a binary search for a value in the list?
- (A) 2
  - (B) 8
  - (C) 64
  - (D) 128

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53. A list of numbers has `n` elements, indexed from 1 to `n`. The following algorithm is intended to display `true` if the value `target` appears in the list more than once and to display `false` otherwise. The algorithm uses the variables `position` and `count`. Steps 4 and 5 are missing.

Step 1: Set `count` to 0 and `position` to 1.

Step 2: If the value of the element at index `position` is equal to `target`, increase the value of `count` by 1.

Step 3: Increase the value of `position` by 1.

Step 4: (missing step)

Step 5: (missing step)

Which of the following could be used to replace steps 4 and 5 so that the algorithm works as intended?

- (A) Step 4: Repeat steps 2 and 3 until the value of `position` is greater than `n`.  
Step 5: If `count` is greater than or equal to 2, display `true`. Otherwise, display `false`.
- (B) Step 4: Repeat steps 2 and 3 until the value of `position` is greater than `n`.  
Step 5: If `count` is greater than or equal to `position`, display `true`. Otherwise, display `false`.
- (C) Step 4: Repeat steps 2 and 3 until the value of `count` is greater than 2.  
Step 5: If `position` is greater than or equal to `n`, display `true`. Otherwise, display `false`.
- (D) Step 4: Repeat steps 2 and 3 until the value of `count` is greater than `n`.  
Step 5: If `count` is greater than or equal to 2, display `true`. Otherwise, display `false`.

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54. Delivery trucks enter and leave a depot through a controlled gate. At the depot, each truck is loaded with packages, which will then be delivered to one or more customers. As each truck enters and leaves the depot, the following information is recorded and uploaded to a database.

- The truck's identification number
- The truck's weight
- The date and time the truck passes through the gate
- Whether the truck is entering or leaving the depot

Using only the information in the database, which of the following questions CANNOT be answered?

- (A) On which day in a particular range of dates did the greatest number of trucks enter and leave the depot?
- (B) What is the average number of customer deliveries made by each truck on a particular day?
- (C) What is the change in weight of a particular truck between when it entered and left the depot?
- (D) Which truck has the shortest average time spent at the depot on a particular day?

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55. A code segment is intended to transform the list `utensils` so that the last element of the list is moved to the beginning of the list.

For example, if `utensils` initially contains `["fork", "spoon", "tongs", "spatula", "whisk"]`, it should contain `["whisk", "fork", "spoon", "tongs", "spatula"]` after executing the code segment.

Which of the following code segments transforms the list as intended?

- (A) 

```
len ← LENGTH(utensils)
temp ← utensils[len]
REMOVE(utensils, len)
APPEND(utensils, temp)
```
- (B) 

```
len ← LENGTH(utensils)
REMOVE(utensils, len)
temp ← utensils[len]
APPEND(utensils, temp)
```
- (C) 

```
len ← LENGTH(utensils)
temp ← utensils[len]
REMOVE(utensils, len)
INSERT(utensils, 1, temp)
```
- (D) 

```
len ← LENGTH(utensils)
REMOVE(utensils, len)
temp ← utensils[len]
INSERT(utensils, 1, temp)
```

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56. Each student at a school has a unique student ID number. A teacher has the following spreadsheets available.

- Spreadsheet I contains information on all students at the school. For each entry in this spreadsheet, the student name, the student ID, and the student's grade point average are included.
- Spreadsheet II contains information on only students who play at least one sport. For each entry in this spreadsheet, the student ID and the names of the sports the student plays are included.
- Spreadsheet III contains information on only students whose grade point average is greater than 3.5. For each entry in this spreadsheet, the student name and the student ID are included.
- Spreadsheet IV contains information on only students who play more than one sport. For each entry in this spreadsheet, the student name and the student ID are included.

The teacher wants to determine whether students who play a sport are more or less likely to have higher grade point averages than students who do not play any sports. Which of the following pairs of spreadsheets can be combined and analyzed to determine the desired information?

- (A) Spreadsheets I and II
- (B) Spreadsheets I and IV
- (C) Spreadsheets II and III
- (D) Spreadsheets III and IV

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57. A certain computer has two identical processors that are able to run in parallel. The following table indicates the amount of time it takes to execute each of four processes on a single processor. Assume that none of the processes is dependent on any of the other processes.

Process	Execution Time on Either Processor
P	30 seconds
Q	10 seconds
R	20 seconds
S	15 seconds

Which of the following parallel computing solutions would minimize the amount of time it takes to execute all four processes?

- (A) Running processes P and Q on one processor and processes R and S on the other processor
- (B) Running processes P and R on one processor and processes Q and S on the other processor
- (C) Running processes P and S on one processor and processes Q and R on the other processor
- (D) Running process P on one processor and processes Q, R, and S on the other processor

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**Questions 58–62 refer to the information below.**

RunRoutr is a fitness tracking application for smartphones that creates suggested running routes so that users can run with each other. Upon downloading the application, each user creates a username, a personal profile, and a contact list of friends who also use the application. The application uses the smartphone's GPS unit to track a user's location, running speed, and distance traveled. Users can use the application to review information and statistics about their previous runs.

At the beginning of a run, users indicate the distance they want to run from their current location, and the application suggests a running route. Once a user accepts a suggested route, the application shares the suggested route with other compatible users in the area so that they can run together. Users are considered compatible if they are on each other's contact lists or if they typically run at similar speeds.

A basic RunRoutr account is free, but it displays advertisements that are targeted to individual users based on data collected by the application. For example, if a user's running route begins or ends near a particular store, the application may display an advertisement for that store. Users have the ability to pay a monthly fee for a premium account, which removes advertisements from the application.

58. Which of the following data must be collected from a user's smartphone in order for RunRoutr to suggest a running route?
- (A) Available running routes near the user's home
  - (B) The current time
  - (C) The starting location of the user's previous run
  - (D) The user's geographic position
- 
59. Adrianna uses RunRoutr to suggest a running route. All compatible users near Adrianna receive a notification that shows her running route. Which of the following data is not obtained using data collected from Adrianna's smartphone but necessary for RunRoutr to share Adrianna's running route?
- (A) Adrianna's average running speed
  - (B) Adrianna's preferred running distance
  - (C) The current locations of other RunRoutr users
  - (D) The usernames on Adrianna's contact list

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60. Which of the following is most likely to be a benefit to users of the application?
- (A) The application allows users to identify all other users in a particular area.
  - (B) Users of the application may be able to easily identify all other users in a particular area as a result of the application's algorithm for determining whether users are compatible.
  - (C) Users of the application may see health benefits as a result of the application encouraging them to exercise with each other.
  - (D) Users of the application who live in rural areas have the ability to use all the features of the application, even when they do not have Internet and geolocation connectivity.
- 

61. Which of the following is most likely to be a data privacy concern for RunRoutr users?
- (A) Users of the application are required to carry their smartphones with them while running in order to enable all of the application's features.
  - (B) Users of the application may have the ability to determine information about the locations of users that are not on their contact lists.
  - (C) Users of the application may not be able to accurately track their running history if they share their smartphone with another family member.
  - (D) Users of the application may not be compatible with any other users in their area.
- 

62. Businesses have the ability to target advertisements to different groups of people who use RunRoutr. Which of the following groups is LEAST likely to receive targeted advertisements?
- (A) Individuals who appear on each other's contact lists
  - (B) Individuals who are interested in running and fitness
  - (C) Individuals who sign up for a premium account
  - (D) Individuals whose running routes begin or end near a particular business location

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### Questions 131–138

**Directions:** For each of the questions or incomplete statements below, two of the suggested answers are correct. For each of these questions, you must select both correct choices to earn credit. No partial credit will be earned if only one correct choice is selected. Select the two that are best in each case and then enter the letters in the corresponding spaces that begin with number 131 on the answer sheet.

131. The following table shows the value of `expression` based on the values of `input1` and `input2`.

Value of <code>input1</code>	Value of <code>input2</code>	Value of <code>expression</code>
true	true	false
true	false	true
false	true	true
false	false	true

Which of the following expressions are equivalent to the value of `expression` as shown in the table?

Select two answers.

- (A) `(NOT input1) OR (NOT input2)`
- (B) `(NOT input1) AND (NOT input2)`
- (C) `NOT (input1 OR input2)`
- (D) `NOT (input1 AND input2)`

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132. In the following procedure, the parameter `age` represents a person's age. The procedure is intended to return the name of the age group associated with `age`. People who are under 18 are considered minors, people who are 65 and older are considered senior citizens, and all other people are considered adults. The procedure does not work as intended.

```
Line 1:  PROCEDURE ageGroup(age)
Line 2:  {
Line 3:      result ← "adult"
Line 4:      IF(age ≥ 65)
Line 5:      {
Line 6:          result ← "senior citizen"
Line 7:      }
Line 8:      RETURN(result)
Line 9:
Line 10:     result ← "adult"
Line 11:     IF(age < 18)
Line 12:     {
Line 13:         result ← "minor"
Line 14:     }
Line 15:     RETURN(result)
Line 16: }
```

Removing which two lines of code will cause the procedure to work as intended?

Select two answers.

- (A) Line 3
- (B) Line 8
- (C) Line 10
- (D) Line 15

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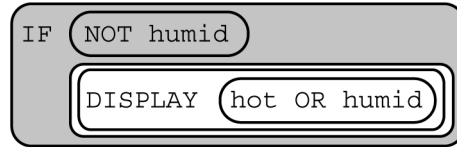
133. Assume that the Boolean variable `hot` is assigned the value `true` and the Boolean variable `humid` is assigned the value `false`. Which of the following will display the value `true` ?

Select two answers.

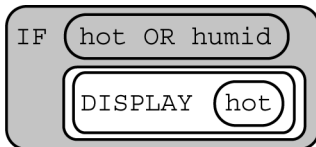
(A)



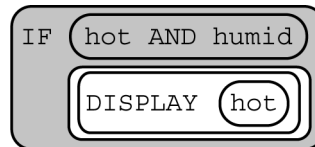
(B)



(C)



(D)



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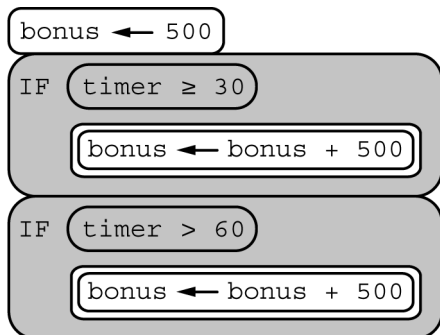
134. In a certain video game, players are awarded bonus points at the end of a level based on the value of the integer variable `timer`. The bonus points are awarded as follows.

- If `timer` is less than 30, then 500 bonus points are awarded.
- If `timer` is between 30 and 60 inclusive, then 1000 bonus points are awarded.
- If `timer` is greater than 60, then 1500 bonus points are awarded.

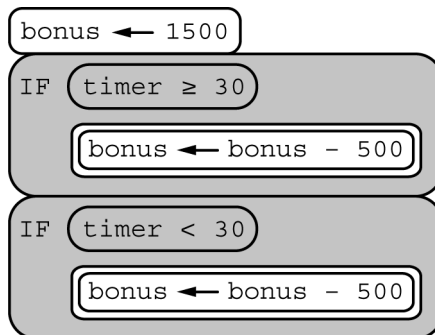
Which of the following code segments assigns the correct number of bonus points to `bonus` for all possible values of `timer` ?

Select two answers.

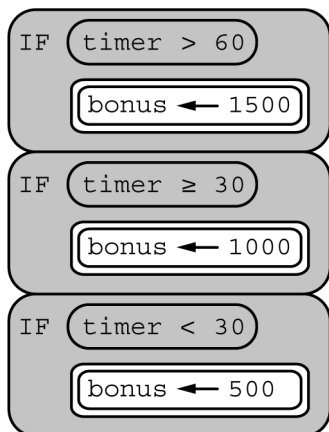
(A)



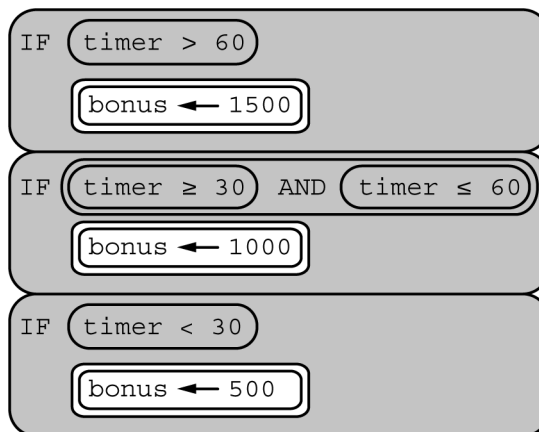
(B)



(C)

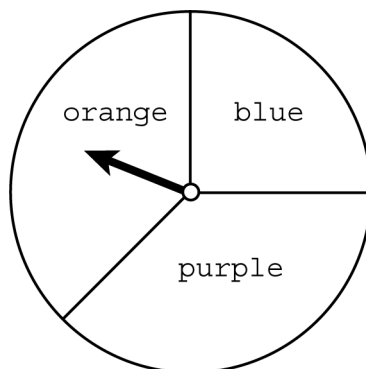


(D)



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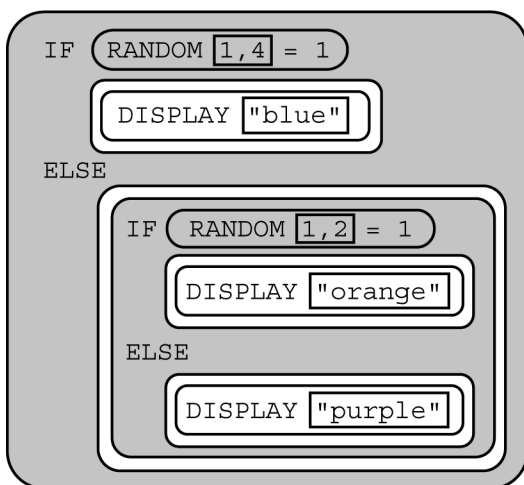
135. The following spinner is used in a game. The region labeled "blue" represents  $\frac{1}{4}$  of the spinner. The regions labeled "orange" and "purple" are equal in size.



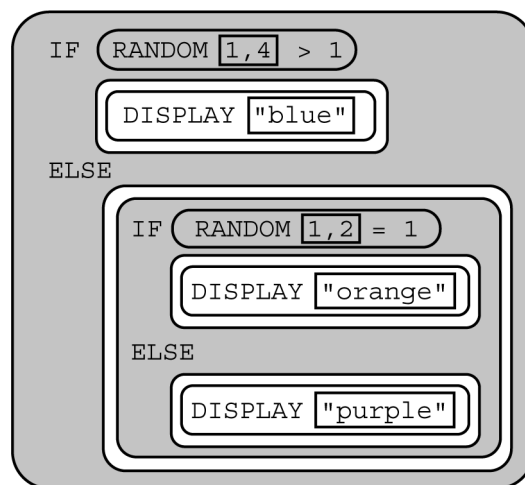
Which of the following code segments can be used to simulate the behavior of the spinner?

Select two answers.

(A)

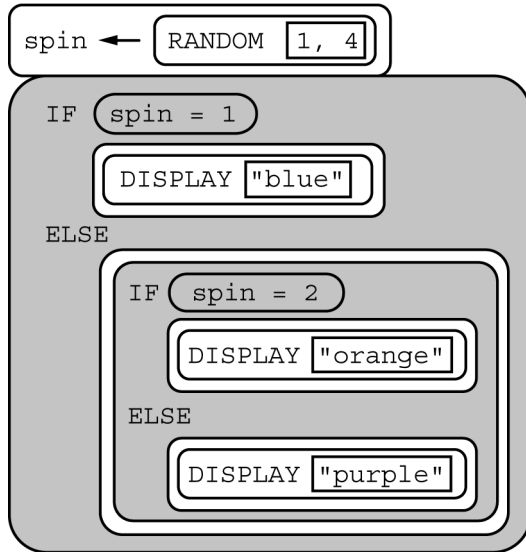


(B)

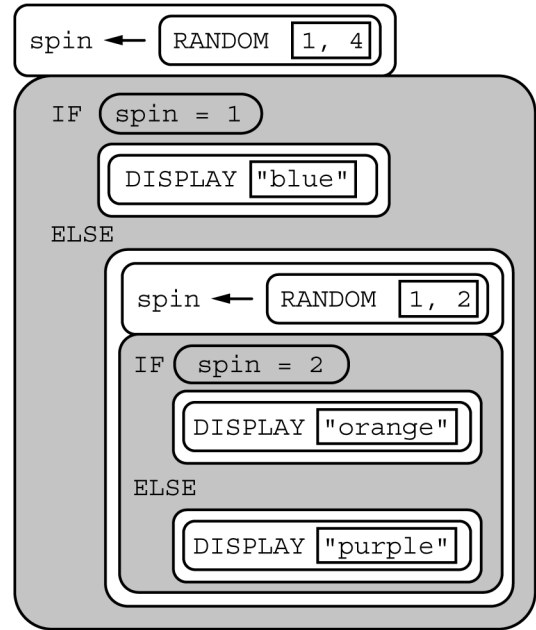


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(C)



(D)



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136. The following code segment is intended to remove all duplicate elements in the list `myList`. The procedure does not work as intended.

```
j ← LENGTH(myList)
REPEAT UNTIL (j = 1)
{
  IF (myList[j] = myList[j - 1])
  {
    REMOVE(myList, j)
  }
  j ← j - 1
}
```

For which of the following contents of `myList` will the procedure NOT produce the intended results?

Select two answers.

- (A) [10, 10, 20, 20, 10, 10]
- (B) [30, 30, 30, 10, 20, 20]
- (C) [30, 50, 40, 10, 20, 40]
- (D) [50, 50, 50, 50, 50, 50]

- 
137. A group of students take hundreds of digital photos for a science project about weather patterns. Each photo file contains data representing the level of red, green, and blue for each pixel in the photo. The file also contains metadata that describes the date, time, and geographic location where the photo was taken. For which of the following goals would analyzing the metadata be more appropriate than analyzing the data?

Select two answers.

- (A) Determining the chronological order of the photos
- (B) Determining the number of clouds in a particular photo
- (C) Determining whether a photo is suitable for printing in black-and-white
- (D) Determining whether two photos were taken at the same location on different days

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138. The following procedures are available for string manipulation.

Procedure Call	Explanation
<code>substring(str, start, end)</code>	Returns a substring of consecutive characters of <code>str</code> starting with the character at position <code>start</code> and ending with the character at position <code>end</code> . The first character of <code>str</code> is considered position 1. For example, <code>substring("delivery", 3, 6)</code> returns "live".
<code>concat(str1, str2)</code>	Returns a single string consisting of <code>str1</code> followed by <code>str2</code> . For example, <code>concat("key", "board")</code> returns "keyboard".
<code>len(str)</code>	Returns the number of characters in <code>str</code> . For example, <code>len("key")</code> returns 3.

A programmer wants to create a new string by removing the character in position `n` of the string `oldStr`. For example, if `oldStr` is "best" and `n` is 3, then the new string should be "bet". Assume that  $1 < n < \text{len}(\text{oldStr})$ .

Which of the following code segments can be used to create the desired new string and store it in `newStr` ?

Select two answers.

- (A) `left ← substring(oldStr, 1, n - 1)`  
`right ← substring(oldStr, n + 1, len(oldStr))`  
`newStr ← concat(left, right)`
- (B) `left ← substring(oldStr, 1, n + 1)`  
`right ← substring(oldStr, n - 1, len(oldStr))`  
`newStr ← concat(left, right)`
- (C) `newStr ← substring(oldStr, 1, n - 1)`  
`newStr ← concat(newStr, substring(oldStr, n + 1, len(oldStr)))`
- (D) `newStr ← substring(oldStr, n + 1, len(oldStr))`  
`newStr ← concat(newStr, substring(oldStr, 1, n - 1))`

**STOP**

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY  
CHECK YOUR WORK ON THIS TEST.**