For the 2020 Exam

AP® CollegeBoard

AP® Computer Science Principles

Practice Exam and Notes

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Contents

Practice Exam

Exam Content and Format

The 2020 AP Computer Science Principles Exam is 2 hours in length and consists of 74 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 74 multiple-choice questions. Each question has 4 answer choices.

- **For question numbers 1 through 66, 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	
2	
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No.	Answer
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56	
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No.	Answer
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62	
63	
64	
65	
66	

131		
132		
133		
134		
135		
136		
137		
138		

AP® 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
74
Percent of Total Score
60%
Writing Instrument
Pencil required
Electronic Device
None allowed

Instructions

This exam booklet contains 74 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 66, 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

74 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
- Robot

REFERENCE MATERIALS

Instruction	Explanation
Assignment, Display, and Input	
Text: `a ← expression` Block: 	Evaluates `expression` and assigns the result to the variable `a`.
Text: `DISPLAY (expression)` Block: 	Displays the value of `expression`, followed by a space.

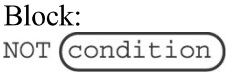
Text:
`INPUT ()`
 	
Block:
`INPUT`
	Accepts a value from the user and returns it.

Arithmetic Operators and Numeric Procedures	

Text and Block:
`a + b`
`a - b`
`a * b`
`a / b`
	The arithmetic operators `+`, `-`, `*`, and `/` are used to perform arithmetic on `a` and `b`.
	
	For example, `3 / 2` evaluates to `1.5`.

Text and Block: `a MOD b`	Evaluates to the remainder when `a` is divided by `b`. Assume that `a` and `b` are positive integers. For example, `17 MOD 5` evaluates to `2`.
Text: `RANDOM (a, b)` Block: 	Evaluates to a random integer from `a` to `b`, including `a` and `b`. For example, `RANDOM (1, 3)` could evaluate to `1`, `2`, or `3`.
Relational and Boolean Operators	

Text and Block:
`a = b`
`a ≠ b`
`a > b`
`a < b`
`a ≥ b`
`a ≤ b`
	The relational operators `=`, `≠`, `>`, `<`, `≥`, and `≤` are used to test the relationship between two variables, expressions, or values.
	
	For example, `a = b` evaluates to `true` if `a` and `b` are equal; otherwise it evaluates to `false`.

Text: `NOT condition` Block: 	Evaluates to `true` if condition is `false`; otherwise evaluates to `false`.
Text: `condition1 AND condition2` Block: 	Evaluates to `true` if both `condition1` and `condition2` are `true`; otherwise evaluates to `false`.

REFERENCE MATERIALS

Instruction	Explanation
Relational and Boolean Operators (continued)	
Text: `condition1 OR condition2` Block: (condition1) OR (condition2)	Evaluates to `true` if `condition1` is `true` or if `condition2` is `true` or if both `condition1` and `condition2` are `true`; otherwise evaluates to `false`.
Selection	

Text:
`IF (condition)`
`{`
`  <block of statements>`
`}`
 	
Block:
IF (condition)
(block of statements)
	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`.

Text:
`IF (condition)`
`{`
`  <first block of statements>`
`}`
`ELSE`
`{`
`  <second block of statements>`
`}`
 	
Block:
IF (condition)
(first block of statements)
ELSE
(second block of statements)
	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.

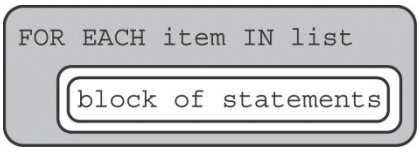
Iteration	

Text:
`REPEAT n TIMES`
`{`
`  <block of statements>`
`}`
 	
Block:
REPEAT n TIMES
(block of statements)
	The code in `block of statements` is executed `n` times.

Instruction	Explanation
Iteration (continued)	

Text:
`REPEAT UNTIL (condition)`
`{`
`  <block of statements>`
`}`
 	
Block:
 
	The code in `block of statements` is repeated until the Boolean expression `condition` evaluates to `true`.

List Operations	
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.	
Text: `list[i]` Block: 	Refers to the element of `list` at index `i`. The first element of `list` is at index `1`.
Text: `list[i] ← list[j]` Block: 	Assigns the value of `list[j]` to `list[i]`.
Text: `list ← [value1, value2, value3]` Block: 	Assigns `value1`, `value2`, and `value3` to `list[1]`, `list[2]`, and `list[3]`, respectively.

Text:
`FOR EACH item IN list`
`{`
`  <block of statements>`
`}`
 	
Block:
 
	The variable `item` is assigned the value of each element of `list` sequentially, in order from the first element to the last element. The code in `block of statements` is executed once for each assignment of `item`.

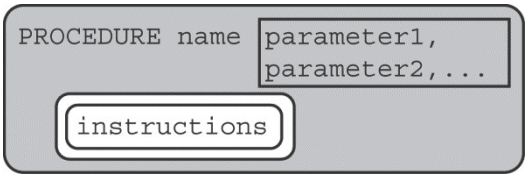
<table>
<tr><th>Instruction</th><th>Explanation</th></tr>
<tr><td colspan="2">List Operations (continued)</td></tr>
<tr><td>Text:
<code>INSERT (list, i, value)</code>

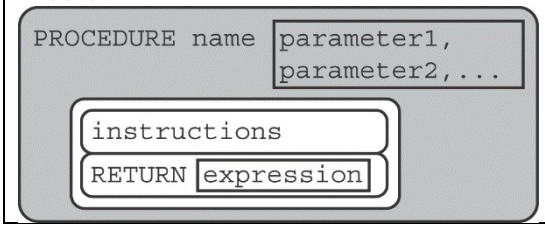
Block:
  </td><td>Any values in <code>list</code> at indices greater than or equal to <code>i</code> are shifted to the right. The length of list is increased by 1, and <code>value</code> is placed at index <code>i</code> in <code>list</code>.</td></tr>
<tr><td>Text:
<code>APPEND (list, value)</code>

Block:
  </td><td>The length of <code>list</code> is increased by 1, and <code>value</code> is placed at the end of <code>list</code>.</td></tr>
<tr><td>Text:
<code>REMOVE (list, i)</code>

Block:
  </td><td>Removes the item at index <code>i</code> in <code>list</code> and shifts to the left any values at indices greater than <code>i</code>. The length of <code>list</code> is decreased by 1.</td></tr>
<tr><td>Text:
<code>LENGTH (list)</code>

Block:
  </td><td>Evaluates to the number of elements in <code>list</code>.</td></tr>
<tr><td colspan="2">Procedures</td></tr>
<tr><td>Text:
<code>PROCEDURE name (parameter1,
parameter2, ...)
{
  <instructions>
}</code>

Block:
  </td><td>A procedure, <code>name</code>, takes zero or more parameters. The procedure contains programming instructions.</td></tr>
<tr><td>Text:
<code>PROCEDURE name (parameter1,
parameter2, ...)
{
  <instructions>
  RETURN (expression)
}</code>

Block:
  </td><td>A procedure, <code>name</code>, takes zero or more parameters. The procedure contains programming instructions and returns the value of <code>expression</code>. 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 program.</td></tr>
</table>

REFERENCE MATERIALS

Instruction	Explanation
Robot	
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:
`MOVE_FORWARD ()`
 	
Block:
`MOVE_FORWARD`
	The robot moves one square forward in the direction it is facing.

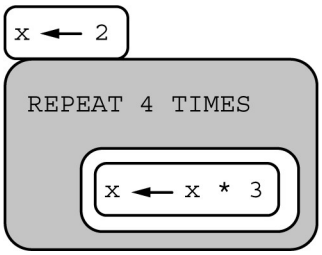
Text:
`ROTATE_LEFT ()`
 	
Block:
`ROTATE_LEFT`
	The robot rotates in place 90 degrees counterclockwise (i.e., makes an in-place left turn).

Text:
`ROTATE_RIGHT ()`
 	
Block:
`ROTATE_RIGHT`
	The robot rotates in place 90 degrees clockwise (i.e., makes an in-place right turn).

Text:
`CAN_MOVE (direction)`
 	
Block:
`CAN_MOVE direction`
	Evaluates to `true` if there is an open square one square in the direction relative to where the robot is facing; otherwise evaluates to `false`. The value of direction can be `left`, `right`, `forward`, or `backward`.

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. Consider the following program.



Which of the following expressions represents the value stored in the variable `x` as a result of executing the program?

(A) `2 * 3 * 3 * 3`

(B) `2 * 4 * 4 * 4`

(C) `2 * 3 * 3 * 3 * 3`

(D) `2 * 4 * 4 * 4 * 4`

---

2. A small team of wildlife researchers is working on a project that uses motion-activated field cameras to capture images of animals at study sites. The team is considering using a "citizen science" approach to analyze the images. Which of the following best explains why such an approach is considered useful for this project?

(A) Distributed individuals are likely to be more accurate in wildlife identification than the research team.

(B) The image analysis is likely to be more consistent if completed by an individual citizen.

(C) The image analysis is likely to require complex research methods.

(D) The image analysis is likely to take a longer time for the research team than for a distributed group of individuals.

GO ON TO THE NEXT PAGE.

3. Of the following software abstractions, which is considered the highest level of abstraction?

   (A) A Boolean expression

   (B) A procedure

   (C) A selection statement

   (D) A software library

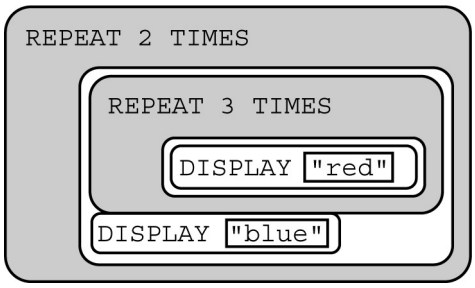
---

4. An algorithm is intended to display the following output.

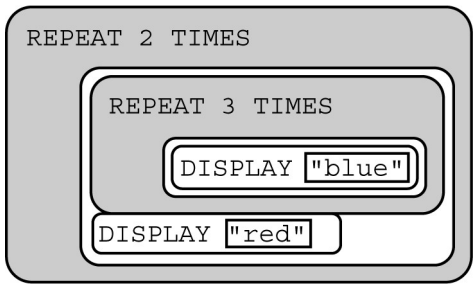
```
red red blue red red blue red red blue
```

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

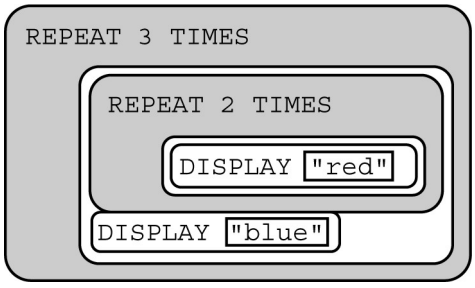
(A)



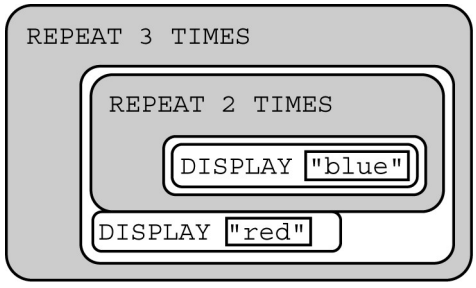
(B)



(C)



(D)



GO ON TO THE NEXT PAGE.

5. Consider the domain names `example.com` and `cs.example.com`. Which of the following best describes the hierarchy of these domain names?

   (A) The domain `example.com` is a subdomain of `cs.example.com`, which is a subdomain of the top-level domain `cs`.

   (B) The domain `example.com` is a subdomain of `cs.example.com`, which is a subdomain of the top-level domain `.com`.

   (C) The domain `cs.example.com` is a subdomain of `example.com`, which is a subdomain of the top-level domain `cs`.

   (D) The domain `cs.example.com` is a subdomain of `example.com`, which is a subdomain of the top-level domain `.com`.

---

6. In a certain computer program, two positive integers are added together, resulting in an overflow error. Which of the following best explains why the error occurs?

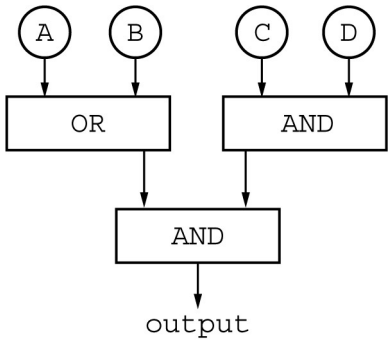
   (A) The program attempted to perform an operation that is considered an undecidable problem.

   (B) The precision of the result is limited due to the constraints of using a floating-point representation.

   (C) The program can only use a fixed number of bits to represent integers; the computed sum is greater than the maximum representable value.

   (D) The program cannot represent integers; the integers are converted into decimal approximations, leading to rounding errors.

7. The diagram below shows a circuit composed of three logic gates. Each gate takes two inputs and produces a single output.



For which of the following input values will the circuit have an output of `true` ?

(A) `A = true, B = true, C = true, D = false`

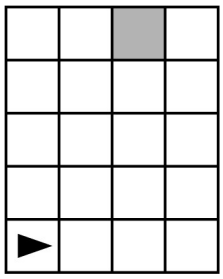
(B) `A = true, B = false, C = false, D = true`

(C) `A = false, B = true, C = true, D = true`

(D) `A = false, B = false, C = true, D = true`

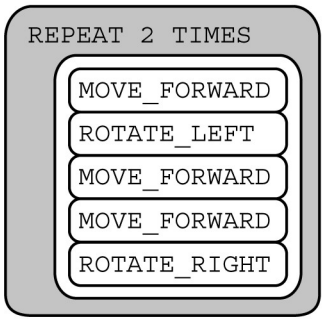
GO ON TO THE NEXT PAGE.

8. The question below 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.

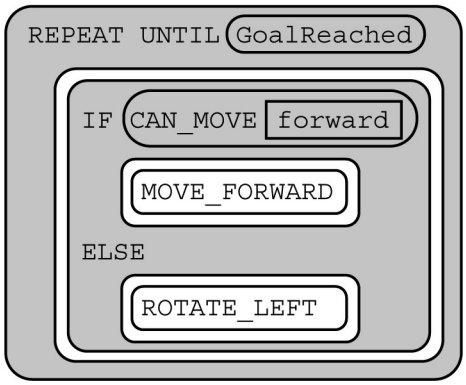


The following programs are each intended to move the robot to the gray square. Program II uses the procedure `GoalReached`, which returns `true` if the robot is in the gray square and returns `false` otherwise.

Program I:



Program II:



Which of the following statements best describes the correctness of the programs?

(A) Program I correctly moves the robot to the gray square, but program II does not.

(B) Program II correctly moves the robot to the gray square, but program I does not.

(C) Both program I and program II correctly move the robot to the gray square.

(D) Neither program I nor program II correctly moves the robot to the gray square.

GO ON TO THE NEXT PAGE.

9. Flight simulation software, which imitates the experience of flying, is often used to train airline pilots. Which of the following is LEAST likely to be an advantage of using flight simulation software for this purpose?

(A) Flight simulation software allows pilots to practice landing in a variety of different terrains and weather conditions without having to physically travel.

(B) Flight simulation software could save money due to the cost of maintenance and fuel for actual training flights.

(C) Flight simulation software provides a more realistic experience for pilots than actual training flights.

(D) Flight simulation software allows for the testing of emergency air situations without serious consequences.

---

10. Which of the following actions are generally helpful in program development?

I. Consulting potential users of the program to identify their concerns

II. Writing and testing small code segments before adding them to the program

III. Collaborating with other individuals when developing a large program

(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

11. An Internet user has a need to send private data to another user. Which of the following provides the most security when transmitting private data?

(A) Certifying the data with a Creative Commons license before sending it

(B) Sending the data using a high-bandwidth connection

(C) Sending the data using public-key encryption

(D) Sending the data using redundant routing

12. Ticket prices for a science museum are shown in the following table.

Type of Ticket	General Admission Cost (in dollars)	Guided Tour Cost (in dollars)
Regular (ages 13 and up)	8	10
Child (ages 12 and below)	6	8

A programmer is creating an algorithm to display the cost of a ticket based on the information in the table. The programmer uses the integer variable `age` for the age of the ticket recipient. The Boolean variable `includesTour` is `true` when the ticket is for a guided tour and is `false` when the ticket is for general admission.

Which of the following code segments correctly displays the cost of a ticket?

(A)
```
cost ← 6
IF ((age > 12) OR includesTour)
{
   cost ← cost + 2
}
DISPLAY (cost)
```

(B)
```
cost ← 6
IF (age > 12)
{
   cost ← cost + 2
}
IF (includesTour)
{
   cost ← cost + 2
}
DISPLAY (cost)
```

(C)
```
cost ← 6
IF (age > 12)
{
   IF (includesTour)
   {
      cost ← cost + 2
   }
}
DISPLAY (cost)
```

(D)
```
cost ← 6
IF (age > 12)
{
   cost ← cost + 2
}
ELSE
{
   IF (includesTour)
   {
      cost ← cost + 2
   }
}
DISPLAY (cost)
```

GO ON TO THE NEXT PAGE.

Questions 13–14 refer to the information below.

A color in a computing application is represented by an RGB triplet that describes the amount of red, green, and blue, respectively, used to create the desired color. A selection of colors and their corresponding RGB triplets are shown in the following table. Each value is represented in decimal (base 10).

Color Name	RGB Triplet
indigo	(75, 0, 130)
ivory	(255, 255, 240)
light pink	(255, 182, 193)
light yellow	(255, 255, 224)
magenta	(255, 0, 255)
neutral gray	(127, 127, 112)
pale yellow	(255, 255, 160)
vivid yellow	(255, 255, 14)

13. According to information in the table, what color is represented by the binary RGB triplet `(11111111, 11111111, 11110000)` ?

    (A) Ivory

    (B) Light yellow

    (C) Neutral gray

    (D) Vivid yellow

14. What is the binary RGB triplet for the color indigo?

    (A) `(00100101, 00000000, 10000010)`

    (B) `(00100101, 00000000, 01000001)`

    (C) `(01001011, 00000000, 10000010)`

    (D) `(01001011, 00000000, 01000001)`

GO ON TO THE NEXT PAGE.

15. A library system contains information for each book that was borrowed. Each time a person borrows or returns a book from the library, the following information is recorded in a database.

- Name and the unique ID number of the person who was borrowing the book
- Author, title, and the unique ID number of the book that was borrowed
- Date that the book was borrowed
- Date that the book was due to be returned
- Date that the book was returned (or 0 if the book has not been returned yet)

Which of the following CANNOT be determined from the information collected by the system?

(A) The total number of books borrowed in a given year

(B) The total number of books that were never borrowed in a given year

(C) The total number of books that were returned past their due date in a given year

(D) The total number of people who borrowed at least one book in a given year

16. The following algorithm is intended to take a positive integer as input and display its individual digits in order from right to left. For example, if the input is `512`, the algorithm should produce the output `2 1 5`. Step `3` of the algorithm is missing.

Step 1: Input a positive integer from the user and store it in the variable `number`.

Step 2: Divide `number` by `10` and record the integer quotient and the remainder. The integer quotient is the quotient with any part after the decimal point dropped. For example, when `127` is divided by `10`, the quotient is `12.7`, the integer quotient is `12` and the remainder is `7`.

Step 3: (missing step)

Step 4: Repeat steps `2` and `3` until `number` is `0`.

Which of the following can be used as step `3` so that the algorithm works as intended?

(A) Step 3: Display the remainder of `number` divided by `10` and store the remainder in `number`.

(B) Step 3: Display the remainder of `number` divided by `10` and store the integer quotient in `number`.

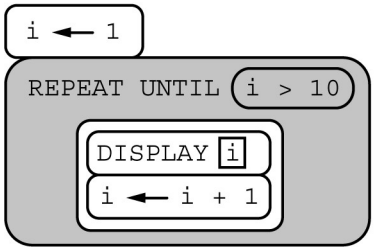
(C) Step 3: Display the integer quotient of `number` divided by `10` and store the remainder in `number`.

(D) Step 3: Display the integer quotient of `number` divided by `10` and store the integer quotient in `number`.

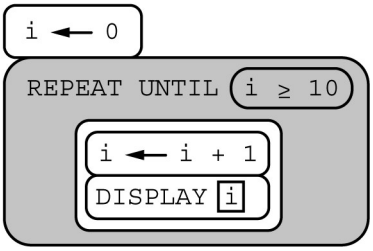
GO ON TO THE NEXT PAGE.

17. Consider the two programs below.

Program A:



Program B:



Which of the following best compares the values displayed by programs A and B?

(A) Program A and program B display identical values in the same order.

(B) Program A and program B display the same values in different orders.

(C) Program A and program B display the same number of values, but the values differ.

(D) Program B displays one more value than program A.

---

18. Which of the following is NOT a way to enhance privacy when browsing the Internet?

(A) Blocking browser cookies

(B) Using online anonymity software

(C) Using proxy servers

(D) Visiting only bookmarked Web sites

GO ON TO THE NEXT PAGE.

19. A student wrote the following program to remove all occurrences of the strings `"the"` and `"a"` from the list `wordList`.

```
Line 1:  index ← LENGTH (wordList)
Line 2:  REPEAT UNTIL (index < 1)
Line 3:  {
Line 4:     IF ((wordList[index] = "the") OR (wordList[index] = "a"))
Line 5:     {
Line 6:        REMOVE (wordList, index)
Line 7:     }
Line 8:  }
```

While debugging the program, the student realizes that the loop never terminates. Which of the following changes can be made so that the program works as intended?

(A) Inserting `index ← index + 1` between lines 6 and 7

(B) Inserting `index ← index + 1` between lines 7 and 8

(C) Inserting `index ← index - 1` between lines 6 and 7

(D) Inserting `index ← index - 1` between lines 7 and 8

---

20. Which of the following can be represented by a sequence of bits?

I. An integer

II. An alphanumeric character

III. A machine language instruction

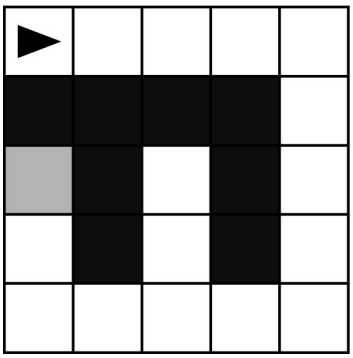
(A) I only

(B) III only

(C) I and II only

(D) I, II, and III

21. The grid below contains a robot represented as a triangle, initially facing right. 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)
```
REPEAT UNTIL (CAN_MOVE (forward) = false)
{
   ROTATE_RIGHT ()
}
MOVE_FORWARD ()
```

(B)
```
REPEAT UNTIL (CAN_MOVE (forward) = false)
{
   MOVE_FORWARD ()
}
ROTATE_RIGHT ()
```

(C)
```
REPEAT UNTIL (CAN_MOVE (right))
{
   ROTATE_RIGHT ()
}
MOVE_FORWARD ()
```

(D)
```
REPEAT UNTIL (CAN_MOVE (right))
{
   MOVE_FORWARD ()
}
ROTATE_RIGHT ()
```

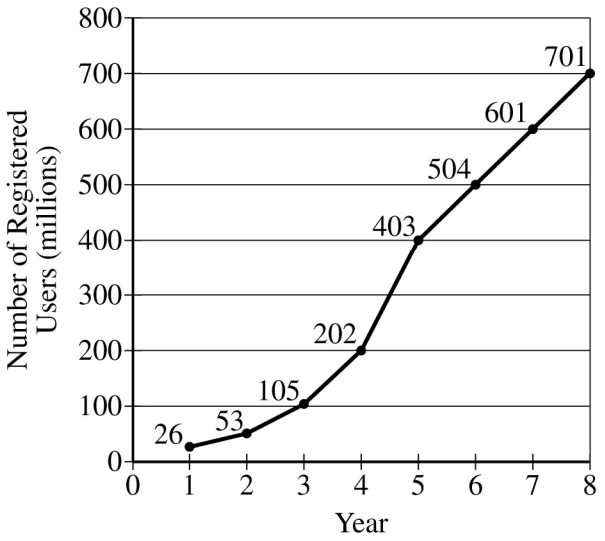
GO ON TO THE NEXT PAGE.

NO TEST MATERIAL ON THIS PAGE

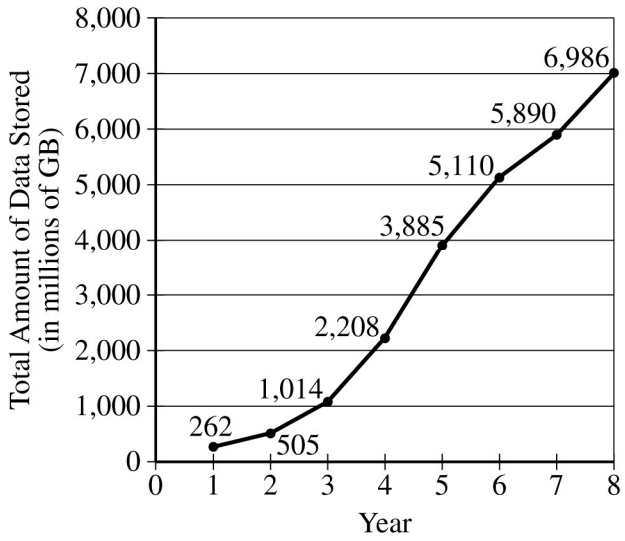
Questions 22–24 refer to the information below.

A file storage application allows users to save their files on cloud servers. A group of researchers gathered user data for the first eight years of the application's existence. Some of the data are summarized in the following graphs. The line graph on the left shows the number of registered users each year. The line graph on the right shows the total amount of data stored by all users each year. The circle graph shows the distribution of file sizes currently stored by all users.

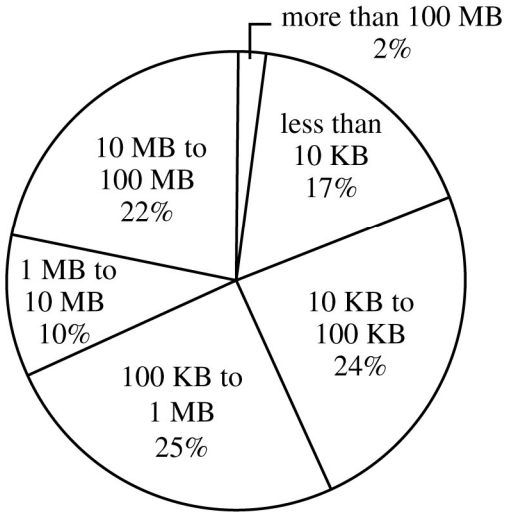
REGISTERED USERS BY YEAR



TOTAL AMOUNT OF DATA STORED



FILE SIZE DISTRIBUTION



(note: 1 MB = 1,000 KB)

GO ON TO THE NEXT PAGE.

22. Which of the following best describes the growth in the number of registered users for the first eight years of the application's existence?

(A) The number of registered users increased at about a constant rate each year for all eight years.

(B) The number of registered users increased at about a constant rate for years 1 to 5 and then about doubled each year after that.

(C) The number of registered users about doubled each year for years 1 to 5 and then increased at about a constant rate after that.

(D) The number of registered users about doubled each year for all eight years.

---

23. Which of the following best describes the average amount of data stored per user for the first eight years of the application's existence?

(A) Across all eight years, the average amount of data stored per user was about 10 GB.

(B) Across all eight years, the average amount of data stored per user was about 100 GB.

(C) The average amount of data stored per user appears to increase by about 10 GB each year.

(D) The average amount of data stored per user appears to increase by about 100 GB each year.

---

24. Which of the following observations is most consistent with the information in the circle graph?

(A) Over 75% of the files stored are 1 MB in size or less.

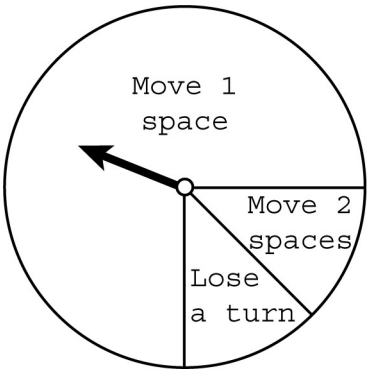
(B) Over 75% of the files stored are 10 MB in size or less.

(C) Over 75% of the files stored are at least 100 KB in size.

(D) Over 75% of the files stored are at least 1 MB in size.

GO ON TO THE NEXT PAGE.

25. Consider the following spinner, which is used to determine how pieces are to be moved on a game board. The region labeled `"Move 1 space"` is six times as large as each of the other two regions.



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

(A)

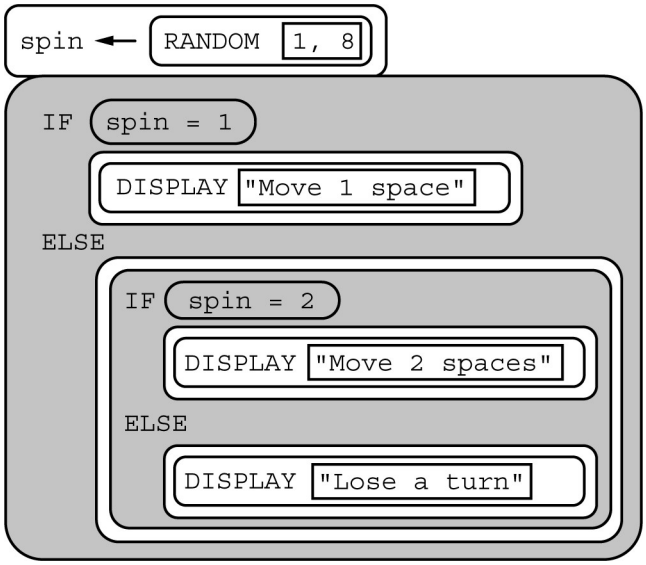
```
spin ← RANDOM 1, 6
IF spin = 1
    DISPLAY "Move 1 space"
ELSE
    IF spin = 2
        DISPLAY "Move 2 spaces"
    ELSE
        DISPLAY "Lose a turn"
```

(B)

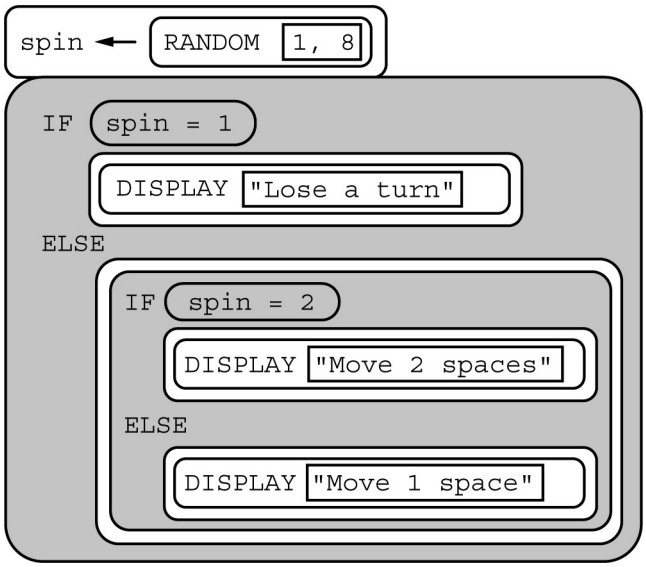
```
spin ← RANDOM 1, 6
IF spin = 1
    DISPLAY "Lose a turn"
ELSE
    IF spin = 2
        DISPLAY "Move 2 spaces"
    ELSE
        DISPLAY "Move 1 space"
```

GO ON TO THE NEXT PAGE.

(C)



(D)



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26. A student is deciding between storing data on the cloud or storing data on a nonnetworked local device. Which of the following is most likely to be true?

(A) The cloud storage solution will allow the data to be accessed by multiple users simultaneously.

(B) The cloud storage solution will ensure that the data can be accessed in the event of a network failure.

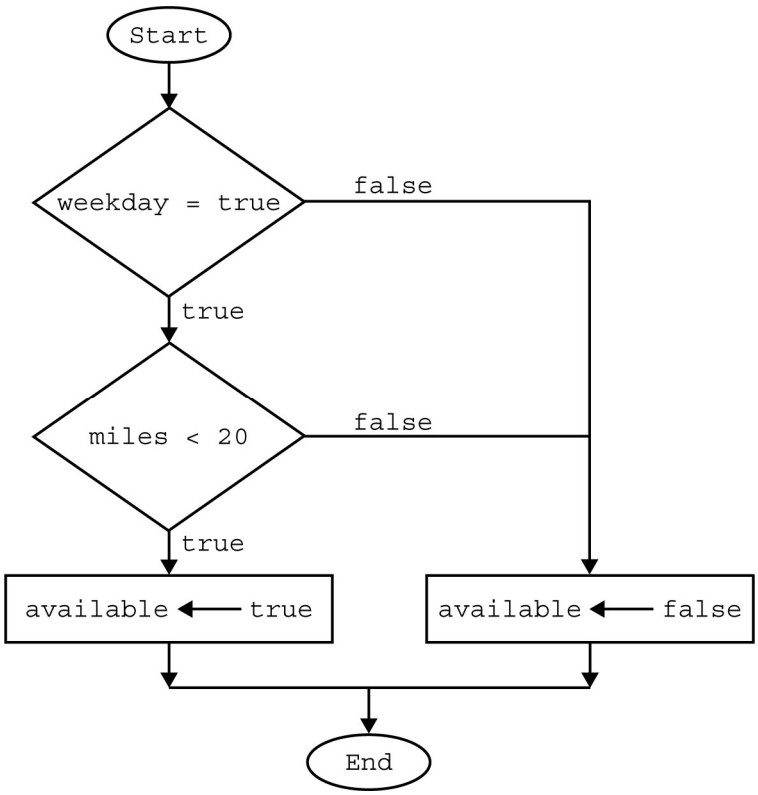
(C) The local device will be more vulnerable to DDoS attacks than the cloud storage solution is.

(D) The local device will ensure that the data is backed up in the event of a hardware failure.

---

27. A flowchart is a way to visually represent an algorithm. The flowchart below is used by an application to set the Boolean variable `available` to `true` under certain conditions. The flowchart uses the Boolean variable `weekday` and the integer variable `miles`.

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



Which of the following statements is equivalent to the algorithm in the flowchart?

(A) available ← weekday OR miles < 20

(B) available ← weekday AND miles < 20

(C) available ← weekday OR miles ≥ 20

(D) available ← weekday AND miles ≥ 20

GO ON TO THE NEXT PAGE.

28. Which of the following is an advantage to representing data in hexadecimal notation instead of binary notation?

(A) A programmer can denote a large value with fewer digits using hexadecimal notation than with binary notation.

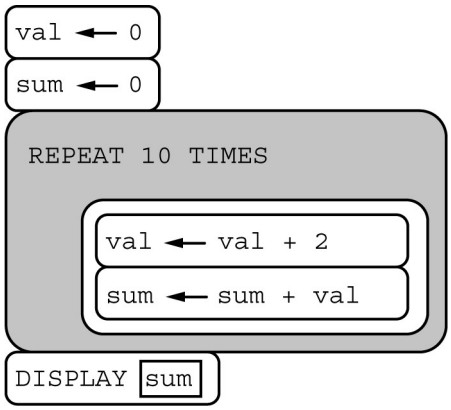
(B) A programmer can denote larger values with hexadecimal notation than with binary notation.

(C) A programmer can detect overflows with hexadecimal notation but not with binary notation.

(D) A programmer can represent hardware abstractions with hexadecimal notation but not with binary notation.

---

29. Consider the following program.



Which of the following describes the result of executing the program?

(A) The program displays the sum of the even integers from 2 to 10.

(B) The program displays the sum of the even integers from 2 to 20.

(C) The program displays the sum of the odd integers from 1 to 9.

(D) The program displays the sum of the odd integers from 1 to 19.

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30. Which of the following statements correctly explain how the Internet is able to facilitate communication at a large scale?

I. A central monitoring computer is used to track and maintain the connections of the Internet.

II. Data is routed between points in multiple ways so that if a connection fails, the data can be rerouted around the inoperative connections.

III. Protocols for packets and routing are used so that computers from different manufacturers can communicate in a standard way.

(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

---

31. A list of binary values (0 or 1) is used to represent a black-and-white image. Which of the following is LEAST likely to be stored as metadata associated with the image?

(A) Copyright information for the image

(B) The date and time the image was created

(C) The dimensions (number of rows and columns of pixels) of the image

(D) A duplicate copy of the data

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32. Which of the following best explains why it is not possible to use computers to solve every problem?

(A) Current computer processing capabilities cannot improve significantly.

(B) Large-scale problems require a crowdsourcing model, which is limited by the number of people available to work on the problem.

(C) The ability of a computer to solve a problem is limited by the bandwidth of the computer's Internet connection.

(D) There exist some problems that cannot be solved using any algorithm.

---

33. Assume that the variables `alpha` and `beta` each are initialized with a numeric value. Which of the following code segments can be used to interchange the values of `alpha` and `beta` using the temporary variable `temp` ?

I.
```
temp ← alpha
alpha ← beta
beta ← temp
```

II.
```
temp ← alpha
beta ← alpha
alpha ← temp
```

III.
```
temp ← beta
beta ← alpha
alpha ← temp
```

(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

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34. A person wants to transmit an audio file from a device to a second device. Which of the following scenarios best demonstrates the use of lossless compression of the original file?

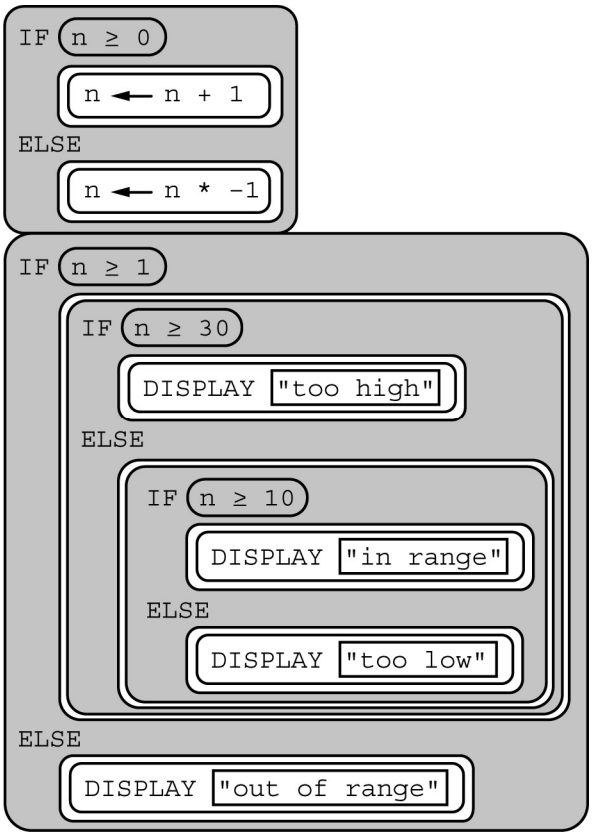
(A) A device compresses the audio file before transmitting it to a second device. The second device restores the compressed file to its original version before playing it.

(B) A device compresses the audio file by removing details that are not easily perceived by the human ear. The compressed file is transmitted to a second device, which plays it.

(C) A device transmits the original audio file to a second device. The second device removes metadata from the file before playing it.

(D) A device transmits the original audio file to a second device. The second device plays the transmitted file as is.

35. In the following program, 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) `too high`

(B) `in range`

(C) `too low`

(D) `out of range`

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36. A student purchases a single-user license of a copyrighted application and wants other students to be able to use it at the same time. Under which of the following conditions is it considered acceptable for the student to share the application?

(A) When the application is shared only with students at the same school

(B) When the application is shared on a peer-to-peer network

(C) When the student gets permission from the copyright owner of the application

(D) When the student makes a copy of the application for another student to use only once

Questions 37–38 refer to the information below.

A student's overall course grade in a certain class is based on the student's scores on individual assignments. The course grade is calculated by dropping the student's lowest individual assignment score and averaging the remaining scores.

For example, if a particular student has individual assignment scores of 85, 75, 90, and 95, the lowest score (75) is dropped. The calculated course grade is $(85 + 90 + 95) / 3 = 90$.

37. A programmer is writing a program to calculate a student's course grade using the process described. The programmer has the following procedures available.

Procedure Call	Explanation
`Min (numList)`	Returns the minimum value in the list `numList`
`Sum (numList)`	Returns the sum of the values in the list `numList`

The student's individual assignment scores are stored in the list `scores`. Which of the following can be used to calculate a student's course grade and store the result in the variable `finalGrade`?

(A)
```
finalGrade ← Sum (scores) / LENGTH (scores)
finalGrade ← finalGrade - Min (scores)
```

(B)
```
finalGrade ← Sum (scores) / (LENGTH (scores) - 1)
finalGrade ← finalGrade - Min (scores)
```

(C)
```
finalGrade ← Sum (scores) - Min (scores)
finalGrade ← finalGrade / LENGTH (scores)
```

(D)
```
finalGrade ← Sum (scores) - Min (scores)
finalGrade ← finalGrade / (LENGTH (scores) - 1)
```

GO ON TO THE NEXT PAGE.

38. An administrator at the school has data about hundreds of students in a particular course. While the administrator does not know the values of each student's individual assignment scores, the administrator does have the following information for each student.

- The student name
- A unique student ID number
- The number of assignments for the course
- The average assignment score before the lowest score was dropped
- The course grade after the lowest score was dropped

Which of the following CANNOT be determined from this data alone?

(A) For a given student, the value of the highest assignment score

(B) For a given student, the value of the lowest assignment score

(C) For a given student, the change in course grade as a result of dropping the lowest score

(D) The proportion of students who improved their course grade as a result of dropping the lowest score

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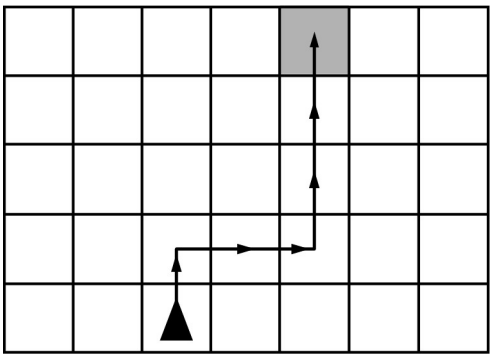
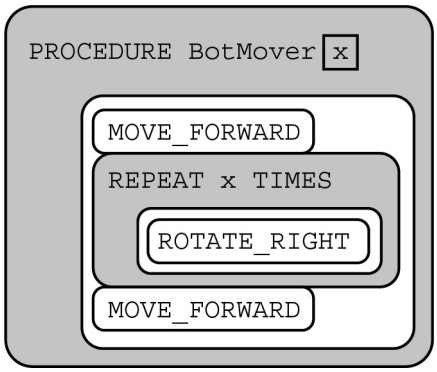
39. The following question uses a robot in a grid of squares. The robot is represented by a triangle, which is initially facing toward the top of the grid.

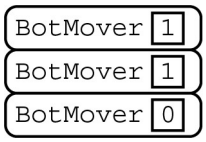


Consider the procedure below.

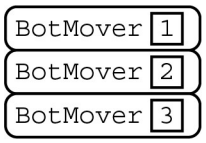


Which of the following code segments will move the robot to the gray square along the path indicated by the arrows?

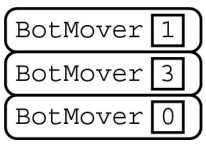
(A)



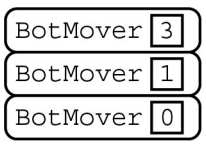
(B)



(C)



(D)



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40. A programmer notices the following two procedures in a library. The procedures do similar, but not identical, things.

- Procedure `MaxTwo (x, y)` returns the greater of its two integer parameters.
- Procedure `MaxThree (x, y, z)` returns the greatest of its three integer parameters.

Which of the following procedures is a generalization of the `MaxTwo` and `MaxThree` procedures?

(A) Procedure `Min (x, y)`, which returns the lesser of its two integer parameters

(B) Procedure `Max (numList)`, which returns the maximum value in the list of integers `numList`

(C) Procedure `MaxFour (w, x, y, z)`, which returns the greatest of its four integer parameters

(D) Procedure `OverMax (numList, max)`, which returns the number of integers in `numList` that exceed the integer value `max`

---

41. A group of planners are using a simulation to examine whether or not a park that they are designing is going to affect foot traffic in the area. The simulation uses a model that includes input variables for the park such as the number of entrances, sidewalks, and bike trails and the square footage of open space (grassy areas). The simulation can then be run multiple times using different values for the input variables to represent different park designs.

However, the simulation takes a very long time to run. The planners update the model by removing some variables they consider less important than others. Of the following, which is the most likely effect the updated model will have on the simulation?

(A) The updated model is likely to decrease the runtime of the simulation because the time required for simulations generally depends on the complexity of the model used.

(B) The updated model is likely to decrease the runtime of the simulation because simulations that use older models tend to require more time to run than simulations that use newer models.

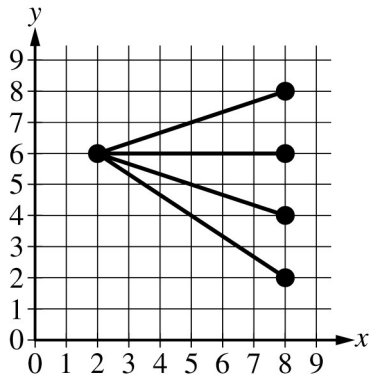
(C) The updated model is unlikely to decrease the runtime of the simulation because the simulation is computationally complex, regardless of the model used.

(D) The updated model is unlikely to provide any benefit because removing details from a model will compromise the accuracy of the simulation.

42. Consider the following procedure.

Procedure Call	Explanation
`DrawLine (x1, y1, x2, y2)`	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.



The following code segment is intended to draw the figure.

```
startX ← 2
startY ← 6
endX ← 8
endY ← 8
REPEAT 4 TIMES
{
   <MISSING CODE>
}
```

Which of the following can be used to replace `<MISSING CODE>` so that the figure is drawn correctly?

(A)
```
DrawLine (startX, startY, endX, endY)
endY ← endY - 2
```

(B)
```
DrawLine (startX, startY, endX, endY)
endX ← endX - 2
endY ← endY - 2
```

(C)
```
endY ← endY - 2
DrawLine (startX, startY, endX, endY)
```

(D)
```
endX ← endX - 2
endY ← endY - 2
DrawLine (startX, startY, endX, endY)
```

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43. Internet protocol version 6 (IPv6) has been introduced to replace the previous version (IPv4). Which of the following best describes a benefit of IPv6 over IPv4 ?

(A) IPv6 addresses are shorter than IPv4 addresses, which allows for faster routing of packets.

(B) IPv6 allows for a greater number of addresses than IPv4, which allows more devices to be connected to the Internet.

(C) IPv6 eliminates the use of hierarchy in addressing, making addresses easier to use.

(D) IPv6 allows users to bypass older security protocols so that data can be sent peer-to-peer without the use of routers.

---

44. Assume that the list of numbers `nums` has more than 10 elements. The program below is intended to compute and display the sum of the first 10 elements of `nums`.

```
Line 1:  i ← 1
Line 2:  sum ← 0
Line 3:  REPEAT UNTIL (i > 10)
Line 4:  {
Line 5:     i ← i + 1
Line 6:     sum ← sum + nums[i]
Line 7:  }
Line 8:  DISPLAY (sum)
```

Which change, if any, is needed for the program to work as intended?

(A) Lines 1 and 2 should be interchanged.

(B) Line 3 should be changed to `REPEAT UNTIL (i ≥ 10)`.

(C) Lines 5 and 6 should be interchanged.

(D) No change is needed; the program works correctly.

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45. Which of the following best explains how a certificate authority is used in protecting data?

(A) A certificate authority certifies the safety of a particular Web site so that users know that it does not contain any viruses.

(B) A certificate authority issues passwords that grant access to secure databases.

(C) A certificate authority maintains a secure database that maps all Web domain names to the IP addresses of the servers where the sites are hosted.

(D) A certificate authority verifies the authenticity of encryption keys used in secured communications.

46. A photographer has a collection of digital pictures, each using the same file-naming format: a date tag, followed by a description, followed by the file extension `".jpg"`. The photographer wants to write a code segment to extract the description from each file name, as shown in the following table.

Original File Name	Extracted Description
`2016-05-22-Andrews-Graduation.jpg`	`Andrews-Graduation`
`2016-07-04-Fireworks.jpg`	`Fireworks`
`2017-10-18-Grandmas-Birthday.jpg`	`Grandmas-Birthday`

The photographer has the following procedures available.

Procedure Call	Explanation
`TrimLeft (str, n)`	Returns a copy of the string `str` with the `n` leftmost characters removed. For example, `TrimLeft ("keyboard", 3)` returns `"board"`.
`TrimRight (str, n)`	Returns a copy of the string `str` with the `n` rightmost characters removed. For example, `TrimRight ("keyboard", 3)` returns `"keybo"`.

Let an original file name be stored in the string variable `original`. Which of the following statements will correctly extract the description and store it in the string variable `descr` ?

I. `descr ← TrimLeft (TrimRight (original, 4), 11)`

II. `descr ← TrimLeft (TrimRight (original, 11), 4)`

III. `descr ← TrimRight (TrimLeft (original, 11), 4)`

(A) I only

(B) II only

(C) I and III

(D) II and III

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47. A programmer wants to determine whether a score is within 10 points of a given target. For example, if the target is 50, then the scores 40, 44, 50, 58, and 60 are all within 10 points of the target, while 38 and 61 are not.

Which of the following Boolean expressions will evaluate to `true` if and only if `score` is within `10` points of `target` ?

(A) `(score ≤ target + 10) AND (target + 10 ≤ score)`

(B) `(target + 10 ≤ score) AND (score ≤ target - 10)`

(C) `(score ≤ target - 10) AND (score ≤ target + 10)`

(D) `(target - 10 ≤ score) AND (score ≤ target + 10)`

---

48. Which of the following best describes the purpose of the domain name system (DNS) ?

(A) To allow users to refer to Web sites using names (such as `example.com`) rather than IP addresses (such as `156.33.241.5`)

(B) To define the standards and protocols to be used for Internet communication

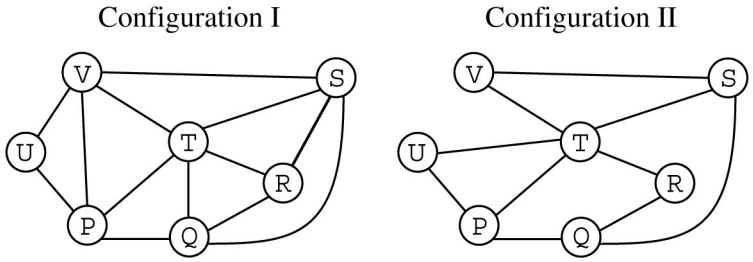
(C) To issue users a digital certificate to enable Internet communication

(D) To prevent devices from attempting to access certain Internet content

GO ON TO THE NEXT PAGE.

Questions 49–50 refer to the information below.

The figure below shows two possible network configurations for devices P through V. A line between two devices indicates a connection. Devices can communicate only through the connections shown.



49. In which of the configurations is it possible to have redundant routing between devices Q and V?

(A) Configuration I only

(B) Configuration II only

(C) Both configuration I and configuration II

(D) Neither configuration I nor configuration II

50. In configuration I, what is the minimum number of connections that must be broken or removed before device T can no longer communicate with device U?

(A) One

(B) Two

(C) Three

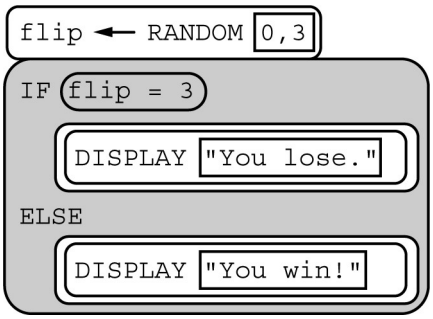
(D) Four

GO ON TO THE NEXT PAGE.

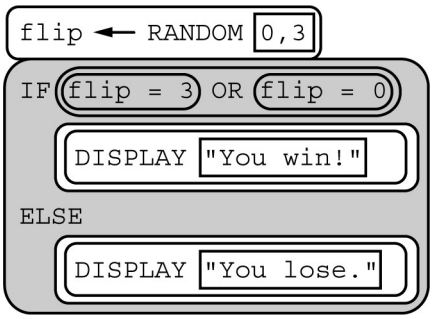
51. Consider a game in which a player flips a fair coin three times. If all three coin flips have the same result (either all heads or all tails) the player wins. Otherwise, the player loses.

Which of the following code segments best simulates the behavior of the game?

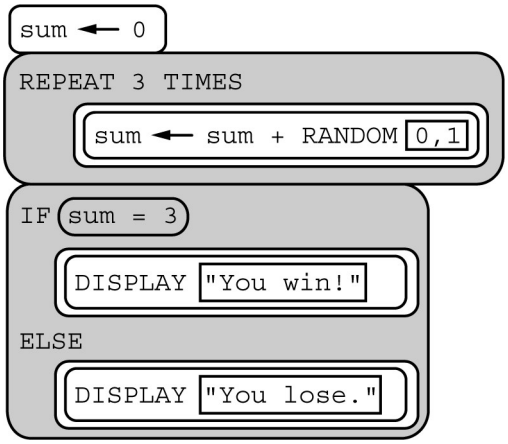
(A)



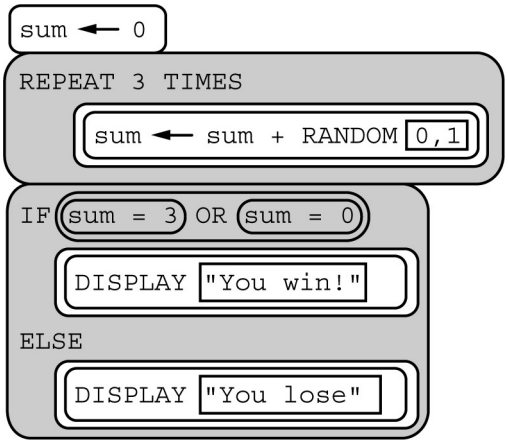
(B)



(C)



(D)



GO ON TO THE NEXT PAGE.

52. Which of the following best explains how IP addresses are assigned?

(A) As a new device is connected to the Internet, it is assigned an IP address to enable communication on the network.

(B) IP addresses are assigned only to servers that host Web sites; user devices do not require an IP address.

(C) New devices are connected to the Internet without an IP address, but are eventually assigned an IP address once they can be verified by a certificate authority.

(D) New devices are connected to the Internet without an IP address; IP addresses are assigned only for encrypted communications.

---

53. The procedure `BinarySearch (numList, target)` correctly implements a binary search algorithm on the list of numbers `numList`. The procedure returns an index where `target` occurs in `numList`, or `-1` if `target` does not occur in `numList`. Which of the following conditions must be met in order for the procedure to work as intended?

(A) The length of `numList` must be even.

(B) The list `numList` must not contain any duplicate values.

(C) The values in `numList` must be in sorted order.

(D) The value of `target` must not be equal to `-1`.

GO ON TO THE NEXT PAGE.

54. Which of the following scenarios best exemplifies a phishing attack?

(A) A user connects to a public wireless network. An unauthorized individual intercepts data transmitted on the network, looking for private information that can be used to gain access to the user's accounts.

(B) A user's e-mail account is overwhelmed with messages containing large attachments, which causes the account to exceed the maximum amount of data allowed and temporarily prevents the user from sending and receiving new messages.

(C) A user receives an e-mail from a sender offering technical help with the user's computer. The e-mail prompts the user to start a help session by clicking a provided link and entering the username and password associated with the user's computer.

(D) A user chooses a weak password for an online account. An unauthorized individual successfully guesses the user's password from a list of common passwords.

---

55. An office uses an application to assign work to its staff members. The application uses a binary sequence to represent each of 100 staff members. What is the minimum number of bits needed to assign a unique bit sequence to each staff member?

(A) 5

(B) 6

(C) 7

(D) 8

56. Consider the following algorithms. Each algorithm operates on a list containing n elements, where n is a very large integer.

I. An algorithm that accesses each element in the list twice

II. An algorithm that accesses each element in the list n times

III. An algorithm that accesses only the first 10 elements in the list, regardless of the size of the list

Which of the algorithms run in reasonable time?

(A) I only

(B) III only

(C) I and II only

(D) I, II, and III

---

57. Which of the following best describes the impact of Creative Commons?

(A) Creative Commons gives creators of digital content the ability to indicate how their works can be legally used and distributed, enabling broad access to digital information.

(B) Creative Commons gives Internet users the right to legally use and distribute any previously copyrighted work, enabling broad access to digital information.

(C) Create Commons provides lossless transmission of messages, enabling reliable distribution of digital information.

(D) Creative Commons provides private transmission of messages, enabling secure distribution of digital information.

58. A biologist wrote a program to simulate the population of a sample of bacteria. The program uses the following procedures.

Procedure Call	Explanation
`InitialPopulation ()`	Returns the number of bacteria at the start of the simulation
`NextPopulation (currPop)`	Based on the current value of `currPop`, returns the number of bacteria after one hour

Code for the simulation is shown below.

```
hours ← 0
startPop ← InitialPopulation ()
currentPop ← startPop
REPEAT UNTIL ((hours ≥ 24) OR (currentPop ≤ 0))
{
   currentPop ← NextPopulation (currentPop)
   hours ← hours + 1
}
DISPLAY (currentPop - startPop)
```

Which of the following are true statements about the simulation?

I. The simulation continues until either 24 hours pass or the population reaches 0.

II. The simulation displays the average change in population per hour over the course of the simulation.

III. The simulation displays the total population at the end of the simulation.

(A) I only

(B) II only

(C) III only

(D) I and II

GO ON TO THE NEXT PAGE.

59. A system is being developed to help pet owners locate lost pets. Which of the following best describes a system that uses crowdsourcing?

(A) A mobile application and collar that uses GPS technology to determine the pet's location and transmits the location when the owner refreshes the application

(B) A mobile application and collar that uses wireless technology to determine whether the pet is within 100 feet of the owner's phone and transmits a message to the owner when the pet is nearby

(C) A mobile application that allows users to report the location of a pet that appears to be lost and upload a photo that is made available to other users of the application

(D) A mobile application that transmits a message to all users any time a lost pet is returned to its owner

---

60. Assume that the list `originalList` contains integer values and that the list `newList` is initially empty. The following code segment is intended to copy all even numbers from `originalList` to `newList` so that the numbers in `newList` appear in the same relative order as in `originalList`. The code segment may or may not work as intended.

```
Line 1:  FOR EACH number IN originalList
Line 2:  {
Line 3:     IF (number MOD 2 = 0)
Line 4:     {
Line 5:        INSERT (newList, 1, number)
Line 6:     }
Line 7:  }
```

Which of the following changes, if any, can be made so that the code segment works as intended?

(A) Changing line 1 to `FOR EACH number IN newList`

(B) Changing line 3 to `IF (number MOD 2 = 1)`

(C) Changing line 5 to `APPEND (newList, number)`

(D) No change is needed; the code segment is correct as is.

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61. The following algorithm is intended to determine the average height, in centimeters, of a group of people in a room. Each person has a card, a pencil, and an eraser. Step 2 of the algorithm is missing.

Step 1: All people stand up.

Step 2: (missing step)

Step 3: Each standing person finds another standing person and they form a pair. If a person cannot find an unpaired standing person, that person remains standing and waits until the next opportunity to form pairs.

Step 4: In each pair, one person hands their card to the other person and sits down.

Step 5: At this point, the standing person in each pair is holding two cards. The standing person in each pair replaces the top number on their card with the sum of the top numbers on the two cards and replaces the bottom number on their card with the sum of the bottom numbers on the two cards. The sitting partner's card is discarded.

Step 6: Repeat steps 3–5 until there is only one person standing.

Step 7: The last person standing divides the top number by the bottom number to determine the average height.

Which of the following can be used as step 2 so that the algorithm works as intended?

(A) Step 2: Each person writes their height, in centimeters, at the top of the card and writes the number 1 at the bottom of the card.

(B) Step 2: Each person writes their height, in centimeters, at the top of the card and writes the number 2 at the bottom of the card.

(C) Step 2: Each person writes the number 1 at the top of the card and writes their height, in centimeters, at the bottom of the card.

(D) Step 2: Each person writes the number 2 at the top of the card and writes their height, in centimeters, at the bottom of the card.

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62. An online game collects data about each player's performance in the game. A program is used to analyze the data to make predictions about how players will perform in a new version of the game.

The procedure `GetPrediction (idNum)` returns a predicted score for the player with ID number `idNum`. Assume that all predicted scores are positive. The `GetPrediction` procedure takes approximately 1 minute to return a result. All other operations happen nearly instantaneously.

Two versions of the program are shown below.

Version I

```
topScore ← 0
idList ← [1298702, 1356846, 8848491, 8675309]
FOR EACH id IN idList
{
   score ← GetPrediction (id)
   IF (score > topScore)
   {
      topScore ← score
   }
}
DISPLAY (topScore)
```

Version II

```
idList ← [1298702, 1356846, 8848491, 8675309]
topID ← idList[1]
FOR EACH id IN idList
{
   IF (GetPrediction (id) > GetPrediction (topID))
   {
      topID ← id
   }
}
DISPLAY (GetPrediction (topID))
```

Which of the following best compares the execution times of the two versions of the program?

(A) Version I requires approximately 1 more minute to execute than version II.

(B) Version I requires approximately 5 more minutes to execute than version II.

(C) Version II requires approximately 1 more minute to execute than version I.

(D) Version II requires approximately 5 more minutes to execute than version I.

GO ON TO THE NEXT PAGE.

63. The transmission control protocol (TCP) and Internet protocol (IP) are used in Internet communication. Which of the following best describes the purpose of these protocols?

(A) To ensure that communications between devices on the Internet are above a minimum transmission speed

(B) To ensure that private data is inaccessible to unauthorized devices on the Internet

(C) To establish a common standard for sending messages between devices on the Internet

(D) To validate the ownership of encryption keys used in Internet communication

---

64. The following procedure is intended to return `true` if at least two of the three parameters are equal in value and is intended to return `false` otherwise.

```
PROCEDURE AnyPairs (x, y, z)
{
   IF (x = y)
   {
      RETURN (true)
   }
   ELSE
   {
      RETURN (y = z)
   }
}
```

For which of the following procedure calls does the procedure NOT return the intended value?

(A) `AnyPairs ("bat", "cat", "rat")`

(B) `AnyPairs ("bat", "bat", "rat")`

(C) `AnyPairs ("bat", "cat", "bat")`

(D) `AnyPairs ("bat", "cat", "cat")`

GO ON TO THE NEXT PAGE.

65. Which of the following is NOT an advantage of using open-source software?

(A) Open-source software is generally free or lower in cost than commercially available software.

(B) The availability of source code makes it possible to customize open-source software to a user's individual needs.

(C) The original developer of open-source software provides free or low-cost support for users installing and running the software.

(D) Unlike commercial software, which can become obsolete when the company that created it goes out of business, open-source software can be updated without the involvement of the original programmers.

66. Consider two lists of numbers called `list1` and `list2`. A programmer wants to determine how many different values appear in both lists. For example, if `list1` contains `[10, 10, 20, 30, 40, 50, 60]` and `list2` contains `[20, 20, 40, 60, 80]`, then there are three different values that appear in both lists (`20`, `40`, and `60`).

The programmer has the following procedures available.

Procedure Call	Explanation
`Combine (myList1, myList2)`	This procedure creates a new list containing the elements from `myList1` followed by the entries from `myList2`. The resulting list is returned. For example, if `myList1` contains `[2, 4, 6]` and `myList2` contains `[1, 5]`, the procedure will return the list `[2, 4, 6, 1, 5]`.
`RemoveAllDups (myList)`	This procedure creates a new list containing the elements of `myList` with any duplicate values removed. The resulting list is returned. For example, if `myList` contains `[3, 2, 4, 2, 2, 5, 6, 4]`, the procedure will return the list `[3, 2, 4, 5, 6]`.

Which of the following can be used to assign the intended value to `count` ?

(A)
```
bothList ← Combine (list1, list2)
uniqueList ← RemoveAllDups (bothList)
count ← LENGTH (bothList) - LENGTH (uniqueList)
```

(B)
```
newList1 ← RemoveAllDups (list1)
newList2 ← RemoveAllDups (list2)
bothList ← Combine (newList1, newList2)
count ← LENGTH (list1) + LENGTH (list2) - LENGTH (bothList)
```

(C)
```
newList1 ← RemoveAllDups (list1)
newList2 ← RemoveAllDups (list2)
bothList ← Combine (newList1, newList2)
count ← LENGTH (newList1) + LENGTH (newList2) - LENGTH (bothList)
```

(D)
```
newList1 ← RemoveAllDups (list1)
newList2 ← RemoveAllDups (list2)
bothList ← Combine (newList1, newList2)
uniqueList ← RemoveAllDups (bothList)
count ← LENGTH (bothList) - LENGTH (uniqueList)
```

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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. Which of the following actions are likely to be helpful in reducing the digital divide?

Select two answers.

(A) Designing new technologies intended only for advanced users

(B) Designing new technologies to be accessible to individuals with different physical abilities

(C) Implementing government regulations restricting citizens' access to Web content

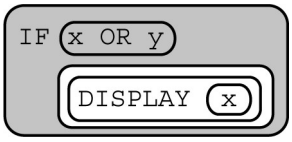
(D) Having world governments support the construction of network infrastructure

132. Assume that the Boolean variable `x` is assigned the value `true` and the Boolean variable `y` is assigned the value `false`. Which of the following will display the value `true` ?

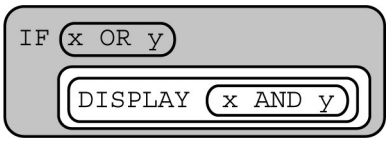
Select two answers.

(A)

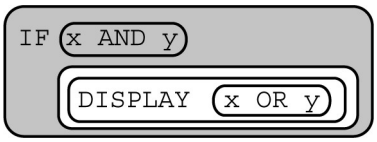
(B)



(C)



(D)



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133. A bookstore has a database containing information about each book for sale in the store. A sample portion of the database is shown below.

Author	Title	Selling Price	Genre	Quantity Available
J. M. Barrie	*Peter and Wendy*	$6.99	Fantasy	3
L. Frank Baum	*The Wonderful Wizard of Oz*	$7.99	Fantasy	2
Arthur Conan Doyle	*The Hound of the Baskervilles*	$7.49	Mystery	4
Mary Shelley	*Frankenstein*	$7.99	Horror	4
Jules Verne	*Twenty Thousand Leagues Under the Sea*	$6.99	Science Fiction	3
H. G. Wells	*The War of the Worlds*	$4.99	Science Fiction	3

A store employee wants to calculate the total amount of money the store will receive if they sell all of the available science fiction books. Which columns in the database can be ignored and still allow the employee to perform this calculation?

Select two answers.

(A) Author

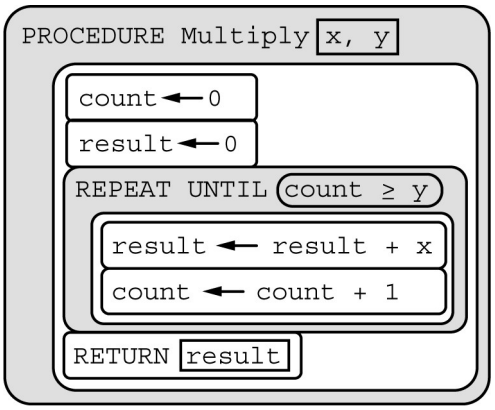
(B) Title

(C) Genre

(D) Quantity Available

GO ON TO THE NEXT PAGE.

134. The following procedure is intended to return the value of `x` times `y`, where `x` and `y` are integers. Multiplication is implemented using repeated additions.



For which of the following procedure calls does the procedure NOT return the intended value?

Select two answers.

(A) `Multiply 2, 5`

(B) `Multiply 2, -5`

(C) `Multiply -2, 5`

(D) `Multiply -2, -5`

GO ON TO THE NEXT PAGE.

135. A program contains the following procedures for string manipulation.

Procedure Call	Explanation
`Concat (str1, str2)`	Returns a single string consisting of `str1` followed by `str2`. For example, `Concat ("key", "board")` returns `"keyboard"`.
`Substring (str, start, length)`	Returns a substring of consecutive characters from `str`, starting with the character at position `start` and containing `length` characters. The first character of `str` is located at position 1. For example, `Substring ("delivery", 3, 4)` returns `"live"`.

Which of the following can be used to store the string `"jackalope"` in the string variable `animal` ?

Select <u>two</u> answers.

(A)
```
animal ← Substring ("antelope", 5, 4)
animal ← Concat (animal, "a")
animal ← Concat (Substring ("jackrabbit", 1, 4), animal)
```

(B)
```
animal ← Substring ("antelope", 5, 4)
animal ← Concat ("a", animal)
animal ← Concat (Substring ("jackrabbit", 1, 4), animal)
```

(C)
```
animal ← Substring ("jackrabbit", 1, 4)
animal ← Concat (animal, "a")
animal ← Concat (animal, Substring ("antelope", 5, 4))
```

(D)
```
animal ← Substring ("jackrabbit", 1, 4)
animal ← Concat (animal, "a")
animal ← Concat (Substring ("antelope", 5, 4), animal)
```

GO ON TO THE NEXT PAGE.

136. Which of the following are examples of DDoS attacks?

Select two answers.

(A) A coordinated group of devices sends thousands of simultaneous requests to an online store in an attempt to make it difficult for customers to complete their purchases.

(B) E-mails are sent to many users who use a Web-based document-editing program. Each e-mail appears to be an invitation to share a document, but is actually a request for permission to access the user's account.

(C) A hacking group, using thousands of bots, sends an overwhelming number of payment requests to a donation site in an attempt to disrupt services over a dispute about how customers' donations are being handled.

(D) Thousands of e-mail messages are sent to targeted companies, appearing to come from different addresses, in the hope that the receivers will click the links embedded in messages.

137. In mathematics, a perfect number is a type of integer. The procedure `IsPerfect (num)` returns `true` if `num` is a perfect number and returns `false` otherwise.

The following program is intended to count and display the number of perfect numbers between the integers `start` and `end`, inclusive. Assume that `start` is less than `end`. The program does not work as intended.

```
Line 1:   currentNum ← start
Line 2:   count ← 0
Line 3:   REPEAT UNTIL (currentNum > end)
Line 4:   {
Line 5:      count ← count + 1
Line 6:      IF (IsPerfect (currentNum))
Line 7:      {
Line 8:         count ← count + 1
Line 9:         currentNum ← currentNum + 1
Line 10:     }
Line 11:     currentNum ← currentNum + 1
Line 12:  }
Line 13:  DISPLAY (count)
```

Which two lines of code should be removed so that the program will work as intended?

Select two answers.

(A) Line 5

(B) Line 8

(C) Line 9

(D) Line 11

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138. The procedure `NumOccurrences` is intended to count and return the number of times `targetWord` appears in the list `wordList`. The procedure does not work as intended.

```
PROCEDURE NumOccurences(wordList, targetWord)
    count ← 0
    FOR EACH word IN wordList
        count ← 0
        IF (word = targetWord)
            count ← count + 1
    RETURN count
```

For which of the following code segments will the call to `NumOccurrences` NOT return the intended value?

Select two answers.

(A)
```
treeList ← ("birch", "maple", "birch")
numOccurences(treeList, "birch")
```

(B)
```
treeList ← ("birch", "maple", "oak")
numOccurences(treeList, "maple")
```

(C)
```
treeList ← ("birch", "maple", "oak")
numOccurences(treeList, "oak")
```

(D)
```
treeList ← ("birch", "maple", "oak")
numOccurences(treeList, "spruce")
```

STOP

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

Notes on the AP Computer Science Principles Practice Exam

Multiple-Choice Section

Course Framework Alignment and Rationales

Question 1

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.2 People write programs to execute algorithms.	5.2.1 Explain how programs implement algorithms.	P3 Abstracting	5.2.1C

(A)	Incorrect. This would be the result if the loop header was changed to `REPEAT 3 TIMES`.
(B)	Incorrect. This would be the result if the loop header was changed to `REPEAT 3 TIMES` and the loop body was changed to `x ← x * 4`.
(C)	**Correct.** The program initializes `x` to `2`, then multiplies it by `3` a total of four times.
(D)	Incorrect. This would be the result if the loop body was changed to `x ← x * 4`.

Question 2

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.1 Computing enhances communication, interaction, and cognition.	7.1.2 Explain how people participate in a problem-solving process that scales.	P4 Analyzing problems and artifacts	7.1.2B 7.1.2C 7.1.2E

(A)	Incorrect. The work may be distributed to amateur or nonprofessional individuals, who are not likely to have the same accuracy as the professional researchers.
(B)	Incorrect. Citizen science is typically conducted with large groups of volunteers, rather than an individual citizen.
(C)	Incorrect. The work may be distributed to amateur or nonprofessional individuals, who are not likely to have training in complex research methods.
(D)	**Correct.** Citizen science involves members of the general public participating in scientific research. Distributing the image analysis work to a larger group of individuals allows the work to be completed in less time.

Question 3

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.2.3D

(A)	Incorrect. Boolean expressions are often contained in selection statements. Selection statements often appear in procedures, which are in turn contained in software libraries.
(B)	Incorrect. Procedures are often contained in software libraries.
(C)	Incorrect. Selection statements are often contained in procedures, which are in turn contained in software libraries.
(D)	**Correct.** Higher-level abstractions are made up of lower-level abstractions. Software libraries typically contain procedures that are available for a programmer to use. Procedures, in turn, can contain Boolean expressions and selection statements. Of the listed abstractions, a software library is considered to be at the highest level.

Question 4

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1D 4.1.1F

(A)	Incorrect. This code segment produces the output `"red red red blue red red red blue"`.
(B)	Incorrect. This code segment produces the output `"blue blue blue red blue blue blue red"`.
(C)	**Correct.** For each iteration of the outer loop, `"red"` is displayed two times and then `"blue"` is displayed one time. The outer loop iterates three times, so `"red red blue"` is displayed three times as intended.
(D)	Incorrect. This code segment produces the output `"blue blue red blue blue red blue blue red"`.

Question 5

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Communicating	6.2.1A 6.2.1B

(A)	Incorrect. For these domains, the top-level domain is `.com`, not `cs`. In addition, `cs.example.com` is a subdomain of `example.com`.
(B)	Incorrect. The domain `cs.example.com` is a subdomain of `example.com`.
(C)	Incorrect. For these domains, the top-level domain is `.com`, not `cs`.
(D)	**Correct.** In the domain name hierarchy, `.com` is a top-level domain. The domain `example.com` is a subdomain of `.com`, and `cs.example.com` is a subdomain of `example.com`.

Question 6

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data.	2.1.2 Explain how binary sequences are used to represent digital data.	P5 Communicating	2.1.2A 2.1.2C

(A)	Incorrect. Arithmetic operations are not considered undecidable. An undecidable problem is one in which no algorithm can be constructed that always leads to a correct yes-or-no answer.
(B)	Incorrect. Floating-point numbers are represented differently from integers. The limitations of floating-point numbers typically result in round-off errors, not overflow errors.
(C)	**Correct.** Overflow errors occur when an arithmetic operation results in a value outside the range of numbers that can be represented by a fixed number of bits.
(D)	Incorrect. While fractions are sometimes represented by decimal approximations that are subject to rounding errors, integers are not.

Question 7

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.2.3E 2.2.3F

(A)	Incorrect. With these inputs, the `OR` gate will produce an output of `true` and the first `AND` gate will produce an output of `false`. Since only one input to the second `AND` gate will be `true`, the circuit will have an output of `false`.
(B)	Incorrect. With these inputs, the `OR` gate will produce an output of `true` and the first `AND` gate will produce an output of `false`. Since only one input to the second `AND` gate will be `true`, the circuit will have an output of `false`.
(C)	**Correct.** With these inputs, the `OR` gate will produce an output of `true` and the first `AND` gate will produce an output of `true`. Since both inputs to the second `AND` gate will be `true`, the circuit will have an output of `true`.
(D)	Incorrect. With these inputs, the `OR` gate will produce an output of `false` and the first `AND` gate will produce an output of `true`. Since only one input to the second `AND` gate will be `true`, the circuit will have an output of `false`.

Question 8

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	5.4.1E 5.4.1F 5.4.1G 5.4.1I 5.4.1K

(A)	Incorrect. Program II correctly moves the robot to the gray square by moving the robot forward to the bottom right corner of the grid, rotating left, moving the robot forward to the upper right corner of the grid, rotating left, and moving forward to the gray square.
(B)	Incorrect. Program I correctly moves the robot to the gray square by repeatedly moving the robot forward, rotating left, moving forward twice, and rotating right.
(C)	**Correct.** Program I correctly moves the robot to the gray square by repeatedly moving the robot forward, rotating left, moving forward twice, and rotating right. Program II correctly moves the robot to the gray square by moving the robot forward to the bottom right corner of the grid, rotating left, moving the robot forward to the upper right corner of the grid, rotating left, and moving forward to the gray square.
(D)	Incorrect. Program I correctly moves the robot to the gray square by repeatedly moving the robot forward, rotating left, moving forward twice, and rotating right. Program II correctly moves the robot to the gray square by moving the robot forward to the bottom right corner of the grid, rotating left, moving the robot forward to the upper right corner of the grid, rotating left, and moving forward to the gray square.

Question 9

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.3.1A 2.3.1B 2.3.1C 2.3.1D

(A)	Incorrect. One of the benefits of using simulations is that they can mimic real-world locations and conditions without needing to travel.
(B)	Incorrect. One of the benefits of using simulations is that they can mimic real-world events while reducing the associated costs.
(C)	**Correct.** While some simulations are realistic, they are simplified representations of more complex objects or phenomena.
(D)	Incorrect. One of the benefits of using simulations is that they can mimic real-world events without any of the danger or risk.

Question 10

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations or society).	5.1.2 Develop a correct program to solve problems.	P2 Creating computational artifacts	5.1.2C 5.1.2D 5.1.2E 5.1.2F 5.1.2G

(A)	Incorrect. Action III is helpful in program development. Collaboration can decrease the size and complexity of tasks required of individual programmers.
(B)	Incorrect. Action II is helpful in program development. Incrementally adding tested program segments to correct working programs helps create large correct programs.
(C)	Incorrect. Action I is helpful in program development. Consultation and communication with program users is an important aspect of program development.
(D)	**Correct.** Actions I, II, and III are all helpful in program development. Consultation and communication with program users is an important aspect of program development. Incrementally adding tested program segments to correct working programs helps create large correct programs. Collaboration can decrease the size and complexity of tasks required of individual programmers.

Question 11

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	6.3.1C 6.3.1H 6.3.1L

(A)	Incorrect. A Creative Commons license allows an individual to publish content while specifying how that content can be legally used or shared. This will not increase the security of private data.
(B)	Incorrect. Private data can be intercepted by an unauthorized individual regardless of the speed of the connection.
(C)	**Correct.** With public-key encryption, any person can encrypt a message using the receiver's public key, but that encrypted message can be decrypted only with the receiver's private key. This provides the sender security in knowing that only the intended recipient can access the data.
(D)	Incorrect. Private data can be intercepted by an unauthorized individual regardless of whether redundant routing is used.

Question 12

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1C

(A)	Incorrect. This code segment initially sets `cost` to `6`, then increases `cost` by `2` for people who are going on a guided tour or whose age is greater than 12. As the cost is only increased once, it is not properly set for people who are both older than 12 and going on a guided tour.
(B)	**Correct.** This code segment initially sets `cost` to `6` (the cheapest possible ticket price), then increases `cost` by `2` for people whose age is greater than 12. Regardless of the person's age, `cost` is increased by `2` for people going on a guided tour.
(C)	Incorrect. This code segment initially sets `cost` to `6`, then increases `cost` by `2` for people who are going on a guided tour and whose age is greater than 12. As a result, regular guided tour tickets are set to `8`, when they should be set to `10`. In addition, regular general admission tickets and child guided tour tickets are set to `6` when they should be set to `8`.
(D)	Incorrect. This code segment initially sets `cost` to `6`, then increases `cost` by `2` for people who are either going on a guided tour or whose age is greater than 12. Because of the `ELSE` statement, the cost is not properly set for people who are both older than 12 and going on a guided tour.

Question 13

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1G

(A)	**Correct.** The binary number `11111111` is equal to $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$, or 255. The binary number `11110000` is equal to $2^7 + 2^6 + 2^5 + 2^4$, or 240. Therefore, the given binary triplet represents the color ivory.
(B)	Incorrect. The binary RGB triplet for light yellow is `(11111111, 11111111, 11100000)`.
(C)	Incorrect. The binary RGB triplet for neutral gray is `(01111111, 01111111, 01110000)`.
(D)	Incorrect. The binary RGB triplet for vivid yellow is `(11111111, 11111111, 00001110)`.

Question 14

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1G

(A)	Incorrect. The decimal equivalent of this triplet is (37, 0, 130).
(B)	Incorrect. The decimal equivalent of this triplet is (37, 0, 65).
(C)	**Correct.** The decimal value 75 is equal to 64 + 8 + 2 + 1, which is equal to $2^6 + 2^3 + 2^1 + 2^0$, which is equal to the binary number `01001011`. The decimal value 0 is equal to the binary number `00000000`. The decimal value 130 is equal to 128 + 2, which is equal to $2^7 + 2^1$, which is equal to the binary number `10000010`.
(D)	Incorrect. The decimal equivalent of this triplet is (75, 0, 65).

Question 15

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	3.2.1A 3.2.1B 3.2.1H 3.2.1I

(A)	Incorrect. This information can be determined using the date each book was borrowed.
(B)	**Correct.** The system only has information for books that were borrowed. Books that have never been borrowed are not represented in the data.
(C)	Incorrect. This information can be determined by comparing the date that each book was due to be returned to the date the book was actually returned.
(D)	Incorrect. This information can be determined by counting the number of unique ID numbers for the people who borrowed at least one book in a given year.

Question 16

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1D

(A)	Incorrect. With this step, the algorithm will result in an infinite loop (unless `number` is a multiple of `10`). For example, if the input is `512`, the algorithm will display the remainder `2`, then store `2` in `number`. The remainder of `2` divided by `10` is also `2`, so `2` will be displayed and then stored in `number` again, and so on. If `number` is a multiple of `10`, the algorithm will display `0` and then terminate.
(B)	**Correct.** With this step, the algorithm will repeatedly perform integer division on `number`, printing the remainder (the rightmost digit) until `number` is `0`. For example, if the input is `512`, the algorithm will display the remainder `2`, then store the integer quotient `51` in `number`, then display the remainder `1`, then store the integer quotient `5` in `number`, then display the remainder `5`, then store the integer quotient `0` in `number`, then terminate.
(C)	Incorrect. With this step, the algorithm will result in an infinite loop (unless `number` is a multiple of `10`). For example, if the input is `512`, the algorithm will display the integer quotient `51`, then store the remainder `2` in `number`, then display the integer quotient `0`, then store the remainder `2` in `number`, and so on. If `number` is a multiple of `10`, the algorithm will display the result of dividing number by `10` and then terminate.
(D)	Incorrect. With this step, the algorithm will not work as intended. For example, if the input is `512`, the algorithm will display `51 5 0` according to the following steps. First, the algorithm will display the integer quotient `51`, then store `51` in `number`, then display the integer quotient `5`, then store `5` in `number`, then display the integer quotient `0`, then store `0` in `number`, then terminate.

Question 17

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.2 People write programs to execute algorithms.	5.2.1 Explain how programs implement algorithms.	P3 Abstracting	5.2.1B 5.2.1C

(A)	**Correct.** Program A initializes `i` to `1`. Inside the loop, it prints `i` and then increments `i`. The loop terminates when `i` is greater than `10`, which occurs after `10` is printed. Program A prints `1 2 3 4 5 6 7 8 9 10`. Program B initializes `i` to `0`. Inside the loop, it increments `i` and then prints `i`. The loop terminates when `i` equals `10`, which occurs after `10` is printed. Program B prints `1 2 3 4 5 6 7 8 9 10`.
(B)	Incorrect. Both programs print the integer values starting at `1` and counting upward to `10`.
(C)	Incorrect. While the two programs initialize `i` to different values, the same values are printed inside the loop because program A prints `i` and then increments it and program B increments `i` and then prints it.
(D)	Incorrect. Both programs print ten values.

Question 18

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.3 Computing has global effects—both beneficial and harmful—on people and society.	7.3.1 Analyze the beneficial and harmful effects of computing.	P4 Analyzing problems and artifacts	7.3.1I 7.3.1G 7.3.1H

(A)	Incorrect. Blocking browser cookies prevents Web sites from gathering a user's browsing history.
(B)	Incorrect. Online anonymity software can be used to hide a user's personally identifiable information when browsing the Web.
(C)	Incorrect. A proxy server can be used to conceal a user's IP address and location, which can help the user remain anonymous when browsing the Web.
(D)	**Correct.** Bookmarking a Web site stores a link to the site in a user's Web browser. As any site can be bookmarked, navigating to only bookmarked sites does not provide any enhanced privacy.

Question 19

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	5.4.1E 5.4.1F 5.4.1I 5.4.1G

(A)	Incorrect. The loop begins at the end of the list and moves to the start of the list, so `index` should be decremented, not incremented. In addition, the decrement should be inserted between lines 7 and 8 to ensure that all elements are checked.
(B)	Incorrect. The loop begins at the end of the list and moves to the start of the list, so `index` should be decremented, not incremented.
(C)	Incorrect. Inserting this statement between lines 6 and 7 means that `index` is only decremented when an occurrence of `"the"` or `"a"` is found. Instead, `index` should be decremented after each element is checked.
(D)	**Correct.** The program traverses `wordList` starting at the end of the list and moving to the start of the list, removing any elements that are equal to `"the"` or `"a"` along the way. Inserting this statement between lines 7 and 8 decrements `index` after checking each list element, ensuring that all elements are checked.

Question 20

Enduring Understanding	Learning Objective	Computational Thinking Practice	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.	P4 Analyzing problems and artifacts	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E

(A)	Incorrect. At the lowest level, all digital data (including alphanumeric characters and machine language instructions) are represented with sequences of bits.
(B)	Incorrect. At the lowest level, all digital data (including integers and alphanumeric characters) are represented with sequences of bits.
(C)	Incorrect. At the lowest level, all digital data (including machine language instructions) are represented with sequences of bits.
(D)	**Correct.** At the lowest level, all digital data (including integers, alphanumeric characters, and machine language instructions) are represented with sequences of bits.

Question 21

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1C 4.1.1D

(A)	Incorrect. This code segment rotates the robot right once, then attempts to move the robot forward into the black region, causing execution to terminate.
(B)	**Correct.** This code segment moves the robot forward whenever there is an open square in front of it. Once there is not an open square in front of it, the robot rotates right. The robot moves forward from its initial location to the upper right corner of the grid, then rotates right, then moves forward to the bottom right corner of the grid, then rotates right, then moves forward to the bottom left corner of the grid, then rotates right, then moves forward two squares to the gray square.
(C)	Incorrect. This code segment rotates the robot right three times until it is facing toward the top of the grid and there is a free space to its right. It then attempts to move the robot forward off the edge of the grid, causing execution to terminate.
(D)	Incorrect. This code segment moves the robot forward to the upper right corner of the grid, then rotates right two times, then moves the robot forward to the upper left corner of the grid. It then attempts to move the robot forward off the edge of the grid, causing execution to terminate.

Question 22

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	3.1.1A 3.1.1D 3.1.1E

(A)	Incorrect. While the number of registered users appears to have grown at a constant rate for years 5 to 8, the number of registered users roughly doubled each year for years 1 to 5.
(B)	Incorrect. From years 1 to 5, the number of registered users roughly doubled each year. From years 5 to 8, the number of registered users increased by about 100 million each year.
(C)	**Correct.** From years 1 to 5, the number of registered users roughly doubled each year. From years 5 to 8, the number of registered users increased by about 100 million each year.
(D)	Incorrect. While the number of registered users appears to have doubled each year for years 1 to 5, the number of registered users grew at a roughly constant rate for years 5 to 8.

Question 23

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	3.1.1A 3.1.1D 3.1.1E

(A)	**Correct.** The two line graphs are roughly the same shape. Each value on the right line graph is about 10 times the corresponding value on the left line graph. Therefore, the average amount of data stored per user is about 10 GB.
(B)	Incorrect. Each value on the right line graph is about 10 times the corresponding value on the left line graph. Therefore, the average amount of data stored per user is about 10 GB, not 100 GB.
(C)	Incorrect. The two line graphs are roughly the same shape, indicating that the average amount of data stored per user remained about the same across all eight years.
(D)	Incorrect. The two line graphs are roughly the same shape, indicating that the average amount of data stored per user remained about the same across all eight years.

Question 24

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	3.1.1A 3.1.1D 3.1.1E

(A)	Incorrect. The files that are up to 1 MB represent 17% + 24% + 25%, or 66%.
(B)	**Correct.** The files that are up to 10 MB represent 17% + 24% + 25% + 10%, or 76%.
(C)	Incorrect. The files that are 100 KB and up represent 25% + 10% + 22% + 2%, or 59%.
(D)	Incorrect. The files that are 1 MB and up represent 10% + 22% + 2%, or 34%.

Question 25

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.3.1A 2.3.1B

(A)	Incorrect. This code segment simulates a spinner in which there is a $\frac{4}{6}$ chance of `"Lose a turn"`, a $\frac{1}{6}$ chance of `"Move 2 spaces"`, and a $\frac{1}{6}$ chance of `"Move 1 space"`. However, the given spinner has a $\frac{6}{8}$ chance of `"Move 1 space"`, a $\frac{1}{8}$ chance of `"Move 2 spaces"`, and a $\frac{1}{8}$ chance of `"Lose a turn"`.
(B)	Incorrect. This code segment simulates a spinner in which there is a $\frac{1}{6}$ chance of `"Lose a turn"`, a $\frac{1}{6}$ chance of `"Move 2 spaces"`, and a $\frac{4}{6}$ chance of `"Move 1 space"`. However, the given spinner has a $\frac{6}{8}$ chance of `"Move 1 space"`, a $\frac{1}{8}$ chance of `"Move 2 spaces"`, and a $\frac{1}{8}$ chance of `"Lose a turn"`.
(C)	Incorrect. This code segment simulates a spinner in which there is a $\frac{6}{8}$ chance of `"Lose a turn"`, a $\frac{1}{8}$ chance of `"Move 2 spaces"`, and a $\frac{1}{8}$ chance of `"Move 1 space"`. However, the given spinner has a $\frac{6}{8}$ chance of `"Move 1 space"`, a $\frac{1}{8}$ chance of `"Move 2 spaces"`, and a $\frac{1}{8}$ chance of `"Lose a turn"`.
(D)	**Correct.** For this spinner, there is a $\frac{1}{8}$ chance of `"Lose a turn"`, a $\frac{1}{8}$ chance of `"Move 2 spaces"`, and a $\frac{6}{8}$ chance of `"Move 1 space"`. The variable `spin` is set to a random value between `1` and `8`. If `spin` is `1` (which occurs $\frac{1}{8}$ of the time), the code segment prints `"Lose a turn"`. If `spin` is `2` (which occurs $\frac{1}{8}$ of the time), the code segment prints `"Move 2 spaces"`. The remaining $\frac{6}{8}$ of the time, the code segment prints `"Move 1 space"`.

Question 26

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	3.3.1G 3.3.1H

(A)	**Correct.** Storing data on the cloud allows it to be accessed from multiple locations. Many cloud services can be configured to allow multiple users to access the data simultaneously.
(B)	Incorrect. Cloud data is stored on network servers, so the data may become inaccessible if the network fails.
(C)	Incorrect. Networked devices (including cloud servers) are susceptible to DDoS attacks, while nonnetworked devices are not.
(D)	Incorrect. The local device is not connected to a network, so it is unable to ensure that the data will be backed up to another location.

Question 27

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1C

(A)	Incorrect. This expression would be equivalent to an algorithm that sets `available` to `true` whenever `weekday` is `true` or `miles` is less than `20`. The algorithm in the flowchart requires both conditions to be `true` in order to set `available` to `true`.
(B)	**Correct.** The flowchart sets `available` to `true` whenever `weekday` is `true` and `miles` is less than `20`, and sets `available` to `false` otherwise. This code statement provides the same functionality.
(C)	Incorrect. This expression would be equivalent to an algorithm that sets `available` to `true` whenever `weekday` is `true` or `miles` is at least `20`. The algorithm in the flowchart requires both conditions to be `true` in order to set `available` to `true`.
(D)	Incorrect. This expression would be equivalent to an algorithm that sets `available` to `true` whenever `weekday` is `true` and `miles` is at least `20`. The algorithm in the flowchart requires both conditions to be `true` in order to set `available` to `true`.

Question 28

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.1.1D 2.1.1F 2.1.1G

(A)	**Correct.** Each hexadecimal digit can hold one of sixteen values, whereas each binary digit can only hold one of two values. Therefore, fewer digits are needed to represent a value in hexadecimal than in binary.
(B)	Incorrect. Numbers can be converted from any base to any other base, so any value that can be represented in binary can also be represented in hexadecimal. The number of digits required for each base may differ.
(C)	Incorrect. Overflow errors can occur whenever a fixed number of digits is used to represent data, regardless of the number base used.
(D)	Incorrect. Hardware abstractions (like logic gates) can be represented as programming instructions, which can in turn be represented in either binary or hexadecimal notation.

Question 29

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.2 People write programs to execute algorithms.	5.2.1 Explain how programs implement algorithms.	P4 Analyzing problems and artifacts	5.2.1A 5.2.1B 5.2.1C 5.2.1D

(A)	Incorrect. The value of `val` starts at `0` and is incremented by `2` a total of ten times, so it the last value added to `sum` is `20`, not `10`.
(B)	**Correct.** The value of `val` starts at `0` and is repeatedly incremented by `2`, so the program calculates the sum of even integers. Inside the loop, `val` is incremented by `2` before being added to sum, so the first value added to sum is `2`. The loop iterates 10 times, adding each intermediate value of `val` each time. Therefore, the program displays the sum of the even integers starting at `2` and ending at `20`.
(C)	Incorrect. The value of `val` starts at `0` and is repeatedly incremented by `2`, so it counts even integers, not odd integers.
(D)	Incorrect. The value of `val` starts at `0` and is repeatedly incremented by `2`, so it counts even integers, not odd integers.

Question 30

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.2 Characteristics of the Internet influence the systems built on it.	6.2.2 Explain how the characteristics of the Internet influence the systems built on it.	P4 Analyzing problems and artifacts	6.2.2A 6.2.2B 6.2.2D 6.2.2E 6.2.2G

(A)	Incorrect. Statement I is false. The Internet is not controlled from a central device. Statement III is true. The Internet uses protocols so that data is transmitted in a standard format.
(B)	Incorrect. Statement I is false. The Internet is not controlled from a central device. Statement II is true. The Internet uses redundant routing to support fault tolerance.
(C)	**Correct.** Statement I is false. The Internet is not controlled from a central device. Statements II and III are true. The Internet uses redundant routing to support fault tolerance. The Internet uses protocols so that data is transmitted in a standard format.
(D)	Incorrect. Statement I is false. The Internet is not controlled from a central device.

Question 31

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	3.2.1G 3.2.1H 3.2.1I

(A)	Incorrect. Metadata is data about data; copyright information is considered descriptive information about the image.
(B)	Incorrect. Metadata is data about data; the date and time the image was created are considered descriptive information about the image.
(C)	Incorrect. Metadata is data about data; the image dimensions are considered descriptive information about the image.
(D)	**Correct.** Metadata typically consists of descriptive information about the data, not a copy of the data itself.

Question 32

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	4.2.2D

(A)	Incorrect. Computer processing capabilities continue to improve, as observed by Moore's law.
(B)	Incorrect. Large-scale problems do not necessarily require a crowdsourcing model to be solved computationally.
(C)	Incorrect. Problems that can be solved computationally can be solved without a connection to the Internet.
(D)	**Correct.** It can be proved that there exist some problems that cannot be solved with any algorithm. These problems cannot be solved computationally.

Question 33

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1B

(A)	Incorrect. Code segment II assigns the initial value of `alpha` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, both variables are assigned the initial value of `alpha`. Code segment III assigns the initial value of `beta` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `beta`, which has been stored in `temp`, is then assigned to `alpha`. Therefore, the values of `alpha` and `beta` are interchanged.
(B)	**Correct.** Code segment I assigns the initial value of `alpha` to `temp`, then assigns the initial value of `beta` to `alpha`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, the values of `alpha` and `beta` are interchanged. Code segment II assigns the initial value of `alpha` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, both variables are assigned the initial value of `alpha`. Code segment III assigns the initial value of `beta` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `beta`, which has been stored in `temp`, is then assigned to `alpha`. Therefore, the values of `alpha` and `beta` are interchanged.
(C)	Incorrect. Code segment I assigns the initial value of `alpha` to `temp`, then assigns the initial value of `beta` to `alpha`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, the values of `alpha` and `beta` are interchanged. Code segment II assigns the initial value of `alpha` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, both variables are assigned the initial value of `alpha`.
(D)	Incorrect. Code segment II assigns the initial value of `alpha` to `temp`, then assigns the initial value of `alpha` to `beta`. The initial value of `alpha`, which has been stored in `temp`, is then assigned to `beta`. Therefore, both variables are assigned the initial value of `alpha`.

Question 34

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	3.3.1C 3.3.1D 3.3.1E

(A)	**Correct.** Lossless compression is a technique that allows for complete reconstruction of the original data.
(B)	Incorrect. This technique is an example of lossy audio compression.
(C)	Incorrect. Removing a file's metadata does not allow for reconstruction of the original data.
(D)	Incorrect. This situation does not make use of any compression.

Question 35

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	5.5.1 Employ appropriate mathematical and logical concepts in programming.	P1 Connecting computing	5.5.1A 5.5.1G

(A)	Incorrect. For example, if `n` is initially `30`, then the first `IF` will be `true` and `n` will be incremented by `1`. The next `IF` condition will also be `true` because `n` is at least `1`. The next `IF` condition will be `true` because `n` is at least `30`. Therefore, `"too high"` will be displayed.
(B)	Incorrect. For example, if `n` is initially `20`, then the first `IF` condition will be `true` and `n` will be incremented by `1`. The next `IF` condition will also be `true` because `n` is at least `1`. The next `IF` condition will be `false` because `n` is less than `30`. The next `IF` condition will be `true` because `n` is at least `10`. Therefore, `"in range"` will be displayed.
(C)	Incorrect. For example, if `n` is initially `5`, then the first `IF` condition will be `true` and `n` will be incremented by `1`. The next `IF` condition will also be `true` because `n` is at least `1`. The next `IF` condition will be `false` because `n` is less than `30`. The next `IF` condition will be `false` because `n` is less than `10`. Therefore, `"too low"` will be displayed.
(D)	**Correct.** The string `"out of range"` could only be displayed if the condition `n ≥ 1` was `false`. If the initial value of `n` is at least `0`, then `n` will be incremented by `1`, making `n` at least `1`. Therefore the condition `n ≥ 1` will be `true` and `"out of range"` will not be displayed. If the initial value of `n` is negative, then `n` will be multiplied by `-1`, making `n` at least `1`. Therefore the condition `n ≥ 1` will be true and `"out of range"` will not be displayed.

Question 36

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.3 Computing has global effects—both beneficial and harmful—on people and society.	7.3.1 Analyze the beneficial and harmful effects of computing.	P4 Analyzing problems and artifacts	7.3.1C 7.3.1F 7.3.1P

(A)	Incorrect. Sharing the software violates the copyright, even if limited to a small number of peers.
(B)	Incorrect. Sharing files on peer-to-peer networks violates copyright.
(C)	**Correct.** In order to share the application without violating copyright, the student should receive permission from the copyright owner.
(D)	Incorrect. Sharing the software violates the copyright, even if it is used only once.

Question 37

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	5.5.1 Employ appropriate mathematical and logical concepts in programming.	P1 Connecting computing	5.5.1A 5.5.1D

(A)	Incorrect. This code segment takes the average of the scores and then subtracts the minimum score, rather than averaging all but the lowest score.
(B)	Incorrect. This code segment divides the sum of the scores by one less than the number of scores and then subtracts the lowest score, rather than averaging all but the lowest score.
(C)	Incorrect. This code segment subtracts the lowest score from the sum. It erroneously divides this result by the number of scores rather than one less than the number of scores.
(D)	**Correct.** This code segment takes the sum of the individual scores and subtracts the lowest score. To obtain the average, the result is divided by one less than the number of scores (since one score was dropped).

Question 38

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	3.2.1A 3.2.1B

(A)	**Correct.** Without knowing the individual assignment scores, the administrator is unable to determine any of the student's individual scores other than the lowest score.
(B)	Incorrect. This information can be determined by calculating the difference between the sum of the scores before the lowest score was dropped and the sum of the scores after the lowest score was dropped.
(C)	Incorrect. This information can be determined by calculating the difference between the original average and the course grade after the lowest score was dropped.
(D)	Incorrect. This information can be determined by comparing each student's original average to the course grade after the lowest score was dropped.

Question 39

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	5.3.1 Use abstraction to manage complexity in programs.	P3 Abstracting	5.3.1A 5.3.1B 5.3.1C 5.3.1D 5.3.1E 5.3.1F 5.3.1G

(A)	Incorrect. In this code segment, the first call to `BotMover` moves the robot forward one square, rotates it right one time so that it faces right, and moves it forward one square. The second call to `BotMover` moves the robot forward one square, rotates it right 1 time so that it faces toward the bottom of the grid, then moves it forward one square. The third call to `BotMover` attempts to moves the robot forward off the edge of the grid.
(B)	Incorrect. In this code segment, the first call to `BotMover` moves the robot forward one square, rotates it right one time so that it faces right, and moves it forward one square. The second call to `BotMover` moves the robot forward one square, rotates it right 2 times so that it faces left , then moves it forward one square. The third call to `BotMover` moves the robot forward one square, rotates it right 3 times so that it faces the bottom of the grid, then moves it forward one square back to where it started.
(C)	**Correct.** In this code segment, the first call to `BotMover` moves the robot forward one square, rotates it right one time so that it faces right, and moves it forward one square. The second call to `BotMover` moves the robot forward one square, rotates it right 3 times so that it faces toward the top of the grid, then moves it forward one square. The third call to `BotMover` moves the robot forward one square, does not rotate it, then moves it forward to the gray square.
(D)	Incorrect. In this code segment, the first call to `BotMover` moves the robot forward one square, rotates it right three times so that it faces left, and moves it forward one square. The second call to `BotMover` moves the robot forward one square, rotates it right 1 time so that it faces toward the top of the grid, then moves it forward one square. The third call to `BotMover` moves the robot forward one square, does not rotate it, then moves it forward one square to the upper left corner of the grid.

Question 40

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts.	2.2.1 Develop an abstraction when writing a program or creating other computational artifacts.	P2 Creating computational artifacts	2.2.1A 2.2.1B 2.2.1C

(A)	Incorrect. The `Min` procedure performs similarly to the `MaxTwo` procedure (in that it compares two values), but it does not generalize this functionality to calculate the maximum of any number of values.
(B)	**Correct.** The procedures `MaxTwo` and `MaxThree` are each used to determine the maximum among a group of given values. A generalization of this procedure is `Max`, which takes a list parameter as input to determine the maximum of any number of values.
(C)	Incorrect. The `MaxFour` procedure calculates a maximum of several values (similar to the `MaxTwo` and `MaxThree` procedures), but it does not generalize this functionality to calculate the maximum of any number of values.
(D)	Incorrect. The `OverMax` procedure compares each element of a list to a given threshold, but it does not generalize the functionality of `MaxTwo` and `MaxThree` to calculate the maximum of any number of values.

Question 41

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.3 Models and simulations use abstraction to generate new understanding and knowledge.	2.3.2 Use models and simulations to formulate, refine, and test hypotheses.	P3 Abstracting	2.3.2G

(A)	**Correct.** The time required for a simulation to run is impacted by the level of detail used in the model. Generally, a simulation based on a less detailed model will require less time to run.
(B)	Incorrect. Whether the model is older or newer is not related to the amount of time it will take to run a simulation.
(C)	Incorrect. Removing detail from the model can often speed up the runtime of a simulation.
(D)	Incorrect. While removing details from the model may lead to a less accurate simulation, it still is likely to provide the benefit of reduced runtime.

Question 42

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Creating computational artifacts	4.1.1A 4.1.1B 4.1.1D

(A)	**Correct.** The code segment draws four line segments, each with a left endpoint at the coordinate `(2, 6)`. The first line segment has a right endpoint at the coordinate `(8, 8)`. The loop repeatedly subtracts two from `endY`, so that the subsequent line segments have their right endpoints at `(8, 6)`, `(8, 4)`, and `(8, 2)`.
(B)	Incorrect. This code segment will draw four line segments: one with endpoints `(2, 6)` and `(8, 8)`, one with endpoints `(2, 6)` and `(6, 6)`, one with endpoints `(2, 6)` and `(4, 4)`, and one with endpoints `(2, 6)` and `(2, 2)`.
(C)	Incorrect. This code segment will draw four line segments: one with endpoints `(2, 6)` and `(8, 6)`, one with endpoints `(2, 6)` and `(8, 4)`, one with endpoints `(2, 6)` and `(8, 2)`, and one with endpoints `(2, 6)` and `(8, 0)`.
(D)	Incorrect. This code segment will draw four line segments: one with endpoints `(2, 6)` and `(6, 6)`, one with endpoints `(2, 6)` and `(4, 4)`, one with endpoints `(2, 6)` and `(2, 2)`, and one with endpoints `(2, 6)` and `(0, 0)`.

Question 43

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems.	6.1.1 Explain the abstractions in the Internet and how the Internet functions.	P3 Abstracting	6.1.1H

(A)	Incorrect. IPv6 addresses are longer than IPv4 addresses. The length of the address has no direct effect on routing speed.
(B)	**Correct.** IPv6 allows for a greater number of IP addresses than IPv4 does, which allows more devices to be connected.
(C)	Incorrect. IP addresses are hierarchical.
(D)	Incorrect. IPv6 does not allow users to bypass security protocols or send data peer-to-peer.

Question 44

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	5.4.1E 5.4.1F 5.4.1G

(A)	Incorrect. Interchanging lines 1 and 2 will have no effect on the output of the program, as the variables can be initialized in either order before entering the loop.
(B)	Incorrect. Making this change to the loop will cause the loop to terminate when `i` is `10`, which does not fix the problem with the program.
(C)	**Correct.** As is, the program does not include the first element of the list in the sum because `i` is incremented before `nums[i]` is added to `sum`. By interchanging these two lines of code, the program will include all of the first ten elements of the list when computing the sum.
(D)	Incorrect. The program does not work as intended, as the first element of the list is not included in the sum.

Question 45

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	6.3.1M

(A)	Incorrect. Certificate authorities do not verify the safety of Web sites.
(B)	Incorrect. Certificate authorities issue digital certificates, not passwords.
(C)	Incorrect. Domain names are translated into IP addresses using the domain name system. This does not fall into the realm of activities performed by certificate authorities.
(D)	**Correct.** Certificate authorities are entities that issue digital certificates, which are used to certify the ownership of public keys.

Question 46

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	5.3.1 Use abstraction to manage complexity in programs.	P3 Abstracting	5.3.1I

(A)	Incorrect. Statement III is correct. It will first call `TrimLeft` to remove the eleven leftmost characters (the date tag). It will then pass the result to `TrimRight`, which will remove the four rightmost characters (the file extension), leaving only the desired description.
(B)	Incorrect. Statement I is correct. It will first call `TrimRight` to remove the four rightmost characters (the file extension). It will then pass the result to `TrimLeft`, which will remove the eleven leftmost characters (the date tag), leaving only the desired description. Statement II is incorrect. It will first call `TrimRight` to remove the eleven rightmost characters, which includes more than just the file extension. It will then pass the result to `TrimLeft` to remove the four leftmost characters, which does not remove the entire date tag. Statement III is correct. It will first call `TrimLeft` to remove the eleven leftmost characters (the date tag). It will then pass the result to `TrimRight`, which will remove the four rightmost characters (the file extension), leaving only the desired description.
(C)	**Correct.** Statement I is correct. It will first call `TrimRight` to remove the four rightmost characters (the file extension). It will then pass the result to `TrimLeft`, which will remove the eleven leftmost characters (the date tag), leaving only the desired description. Statement II is incorrect. It will first call `TrimRight` to remove the eleven rightmost characters, which includes more than just the file extension. It will then pass the result to `TrimLeft` to remove the four leftmost characters, which does not remove the entire date tag. Statement III is correct. It will first call `TrimLeft` to remove the eleven leftmost characters (the date tag). It will then pass the result to `TrimRight`, which will remove the four rightmost characters (the file extension), leaving only the desired description.
(D)	Incorrect. Statement I is correct. It will first call `TrimRight` to remove the four rightmost characters (the file extension). It will then pass the result to `TrimLeft`, which will remove the eleven leftmost characters (the date tag), leaving only the desired description. Statement II is incorrect. It will first call `TrimRight` to remove the eleven rightmost characters, which includes more than just the file extension. It will then pass the result to `TrimLeft` to remove the four leftmost characters, which does not remove the entire date tag.

Question 47

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	5.5.1 Employ appropriate mathematical and logical concepts in programming.	P4 Analyzing problems and artifacts	5.5.1A 5.5.1D 5.5.1E 5.5.1F 5.5.1G

(A)	Incorrect. This Boolean expression does not work as intended. For example, if `score` is `44` and `target` is `50`, then `(score ≤ target + 10)` evaluates to `true` and `(target + 10 ≤ score)` evaluates to `false`. Therefore this Boolean expression will evaluate to `false` when it should evaluate to `true`.
(B)	Incorrect. This Boolean expression does not work as intended. For example, if `score` is `44` and `target` is `50`, then `(target + 10 ≤ score)` evaluates to `false` and `(score ≤ target - 10)` evaluates to `false`. Therefore this Boolean expression will evaluate to `false` when it should evaluate to `true`.
(C)	Incorrect. This Boolean expression does not work as intended. For example, if score is `44` and `target` is `50`, then `(score ≤ target - 10)` evaluates to `false` and `(score ≤ target + 10)` evaluates to `true`. Therefore this Boolean expression will evaluate to `false` when it should evaluate to `true`.
(D)	**Correct.** This Boolean expression is `true` if and only if `score` is between `target - 10` and `target + 10`, inclusive. Therefore, it evaluates to `true` if and only if `score` is in the desired range.

Question 48

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems.	6.1.1 Explain the abstractions in the Internet and how the Internet functions.	P3 Abstracting	6.1.1G

(A)	**Correct.** The DNS translates domain names to IP addresses so that users can navigate to a Web site without needing to know its IP address.
(B)	Incorrect. Internet standards and protocols are developed by the Internet Engineering Task Force, not the DNS.
(C)	Incorrect. Digital certificates, which are used to validate encryption keys, are issued by certificate authorities, not the DNS.
(D)	Incorrect. Devices are blocked from accessing certain Internet content by firewalls, not the DNS.

Question 49

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Communicating	6.2.1A 6.2.1D

(A)	Incorrect. It is possible to have redundant routing in both configurations. In configuration II, some possible routes between computers Q and V include Q-S-V, Q-R-T-V, and Q-P-T-V.
(B)	Incorrect. It is possible to have redundant routing in both configurations. In configuration I, some possible routes between computers Q and V include Q-P-V, Q-T-V, and Q-R-S-V.
(C)	**Correct.** It is possible to have redundant routing in both configurations. In configuration I, some possible routes between computers Q and V include Q-P-V, Q-T-V, and Q-R-S-V. In configuration II, some possible routes between computers Q and V include Q-S-V, Q-R-T-V, and Q-P-T-V.
(D)	Incorrect. It is possible to have redundant routing in both configurations. In configuration I, some possible routes between computers Q and V include Q-P-V, Q-T-V, and Q-R-S-V. In configuration II, some possible routes between computers Q and V include Q-S-V, Q-R-T-V, and Q-P-T-V.

Question 50

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Communicating	6.2.1A 6.2.1D

(A)	Incorrect. Removing any single connection will not prevent computers U and T from communicating.
(B)	**Correct.** If the connections between U and V and between U and P were removed, then computer T and computer U can no longer communicate.
(C)	Incorrect. While it is possible to disconnect computers U and T by removing three connections, it can be done by removing only two connections.
(D)	Incorrect. While it is possible to disconnect computers U and T by removing four connections, it can be done by removing only two connections.

Question 51

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.3.1A 2.3.1B

(A)	Incorrect. In this code segment, the variable `flip` is assigned one of four values: `0`, `1`, `2`, or `3`. The player wins approximately three out of every four times (when `flip` is not `3`).
(B)	Incorrect. In this code segment, the variable `flip` is assigned one of four values: `0`, `1`, `2`, or `3`. The player wins approximately two out of every four times (when `flip` is `0` or `3`).
(C)	Incorrect. In this code segment, three coin flips are simulated, where one result is represented by `1` and the other result is represented by `0`. The player only wins when the sum of these is `3`. However, the player should also win when the sum is `0`.
(D)	**Correct.** In this code segment, three coin flips are simulated, where one result is represented by `1` and the other result is represented by `0`. The player wins when the sum of these is `0` or `3`, indicating all heads or all tails.

Question 52

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems.	6.1.1 Explain the abstractions in the Internet and how the Internet functions.	P3 Abstracting	6.1.1C 6.1.1E 6.1.1F

(A)	**Correct.** Every device connected to the Internet is assigned an IP address, which is used to enable communication using the Internet protocol.
(B)	Incorrect. While servers that host Web sites have IP addresses, user devices have IP addresses as well.
(C)	Incorrect. All Internet-connected devices are assigned an IP address. Certificate authorities are used to validate encryption keys.
(D)	Incorrect. All Internet-connected devices are assigned an IP address, regardless of whether they use encryption.

Question 53

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	4.2.4H

(A)	Incorrect. A binary search will work on any sorted list, regardless of whether the list contains an even or odd number of elements.
(B)	Incorrect. A binary search will work on any sorted list, regardless of whether the list contains any duplicate values.
(C)	**Correct.** In order for a binary search on a list to work as intended, the list must be sorted.
(D)	Incorrect. If `target` is `-1`, the procedure will work as intended. It will return an index where `-1` appears in the list or `-1` if it does not appear in the list.

Question 54

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	6.3.1F

(A)	Incorrect. Data sent over public networks can be intercepted and analyzed without tricking the user into providing personal information.
(B)	Incorrect. Flooding an account with fraudulent traffic is considered a denial-of-service attack.
(C)	**Correct.** Phishing is a technique that is used to trick a user into providing personal information. In this case, the user is tricked into providing a username and password to an unauthorized individual posing as a technical support specialist.
(D)	Incorrect. Guessing a user's weak password from a list of common passwords does not require the user to be tricked into providing personal information.

Question 55

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Abstracting	2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1G

(A)	Incorrect. Using 5 bits will only allow for up to 32 employees ($2^5 = 32$).
(B)	Incorrect. Using 6 bits will only allow for up to 64 employees ($2^6 = 64$).
(C)	**Correct.** Using 7 bits will allow for up to 128 employees ($2^7 = 128$).
(D)	Incorrect. Using 8 bits will allow for up to 256 employees ($2^8 = 256$). However, a unique bit sequence can be assigned to each employee using only 7 bits.

Question 56

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems.	4.2.1 Explain the difference between algorithms that run in a reasonable time and those that do not run in a reasonable time.	P1 Connecting computing	4.2.1A 4.2.1B

(A)	Incorrect. Algorithm II accesses n^2 elements (n times for each of n elements), which is considered reasonable time. Algorithm III accesses 10 elements, which is considered reasonable time.
(B)	Incorrect. Algorithm I accesses elements $2n$ times (twice for each of n elements), which is considered reasonable time. Algorithm II accesses n^2 elements (n times for each of n elements), which is considered reasonable time.
(C)	Incorrect. Algorithm III accesses 10 elements, which is considered reasonable time.
(D)	**Correct.** For an algorithm to run in reasonable time, it must take a number of steps less than or equal to a polynomial function. Algorithm I accesses elements $2n$ times (twice for each of n elements), which is considered reasonable time. Algorithm II accesses n^2 elements (n times for each of n elements), which is considered reasonable time. Algorithm III accesses 10 elements, which is considered reasonable time.

Question 57

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.2 Computing enables innovation in nearly every field.	7.2.1 Explain how computing has impacted innovations in other fields.	P1 Connecting computing	7.2.1D

(A)	**Correct.** Creative Commons licensing allows copyright owners to specify the ways in which their works can be used or distributed. This allows individuals to access or modify these works without the risk of violating copyright laws.
(B)	Incorrect. The benefits of Creative Commons are limited to works that are published with a Creative Commons license. Previously published works are subject to traditional copyright rules.
(C)	Incorrect. Creative Commons licenses do not affect the reliability of transmitted information.
(D)	Incorrect. Creative Commons licenses do not affect the security of transmitted information.

Question 58

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.3 Models and simulations use abstraction to generate new understanding and knowledge.	2.3.2 Use models and simulations to formulate, refine, and test hypotheses.	P3 Abstracting	2.3.2E

(A)	**Correct.** Statement I is true. The `REPEAT UNTIL` loop terminates when `hours` is at least `24` or `currentPop` is at most `0`. Statements II and III are false. The simulation displays the change in population over the entire course of the simulation.
(B)	Incorrect. Statement I is true. The `REPEAT UNTIL` loop terminates when `hours` is at least `24` or `currentPop` is at most `0`. Statement II is false. The simulation displays the change in population over the entire course of the simulation.
(C)	Incorrect. Statement I is true. The `REPEAT UNTIL` loop terminates when `hours` is at least `24` or `currentPop` is at most `0`. Statement III is false. The simulation displays the change in population over the entire course of the simulation.
(D)	Incorrect. Statement II is false. The simulation displays the change in population over the entire course of the simulation.

Question 59

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.1 Computing enhances communication, interaction, and cognition.	7.1.2 Explain how people participate in a problem-solving process that scales.	P4 Analyzing problems and artifacts	7.1.2F

(A)	Incorrect. This system uses GPS technology to find a lost pet, rather than the contributions of many individuals.
(B)	Incorrect. This system uses wireless technology to find a lost pet, rather than the contributions of many individuals.
(C)	**Correct.** This system uses an application to enlist the services of a large number of people to help find a lost pet.
(D)	Incorrect. This system sends a message to many individuals, but does not enlist their help in finding a lost pet.

Question 60

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	5.4.1F

(A)	Incorrect. The loop should traverse all elements of `originalList`, not all elements of `newList`.
(B)	Incorrect. This change will add only odd elements from `originalList` to `newList` instead of adding even elements.
(C)	**Correct.** The given code segment traverses `originalList` from left to right and inserts all even elements at the beginning of `newList`. Repeatedly inserting these elements at the beginning of `newList` causes `newList` to have the copied elements appear in reverse order compared to their order in `originalList`. By changing line 5 to `APPEND (newList, number)`, even values are added to the end of `newList`, ensuring that they will appear in the same relative order as they did in `originalList`.
(D)	Incorrect. The given code segment inserts even elements from `oldList` at the beginning of `newList`, causing the elements to appear in reverse order.

Question 61

Enduring Understanding	Learning Objective	Computational Thinking Practice	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.	P4 Analyzing problems and artifacts	4.1.1A 4.1.1B 4.1.1C 4.1.1D

(A)	**Correct.** By starting the process by writing a height at the top of the card and writing a 1 at the bottom of the card, the algorithm will work such that the last person's card will have the sum of the heights at the top and the number of people at the bottom. The sum of the heights divided by the number of people gives the average height.
(B)	Incorrect. By starting the process by writing a height at the top of the card and writing a 2 at the bottom of the card, the algorithm will work such that the last person's card will have the sum of the heights at the top and two times the number of people at the bottom. Dividing the top by the bottom will give half the average height instead of the average height.
(C)	Incorrect. By starting the process by writing a 1 at the top of the card and writing a height at the bottom of the card, the algorithm will work such that the last person's card will have the number of people at the top and the sum of the heights at the bottom. Dividing the top by the bottom will give the inverse of the average instead of the average.
(D)	Incorrect. By starting the process by writing a 2 at the top of the card and writing a height at the bottom of the card, the algorithm will work such that the last person's card will have twice the number of people at the top and the sum of the heights at the bottom. Dividing the top by the bottom will give the twice the inverse of the average instead of the average.

Question 62

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	4.2.4A 4.2.4G

(A)	Incorrect. Version I calls `GetPrediction` once for each element of `idList`, while version II calls `GetPrediction` twice for each element of `idList` (plus one more time at the end). Therefore, version II takes longer than version I.
(B)	Incorrect. Version I calls `GetPrediction` once for each element of `idList`, while version II calls `GetPrediction` twice for each element of `idList` (plus one more time at the end). Therefore, version II takes longer than version I.
(C)	Incorrect. Version I calls `GetPrediction` once for each element of `idList`, while version II calls `GetPrediction` twice for each element of `idList` (plus one more time at the end). Therefore, version II takes more than 1 minute longer than version I.
(D)	**Correct.** Version I calls the `GetPrediction` procedure once for each element of `idList`, or four times total. Since each call requires 1 minute of execution time, version I requires approximately 4 minutes to execute. Version II calls the `GetPrediction` procedure twice for each element of `idList`, and then again in the final display statement. This results in the procedure being called nine times, requiring approximately 9 minutes of execution time.

Question 63

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems.	6.1.1 Explain the abstractions in the Internet and how the Internet functions.	P3 Abstracting	6.1.1C

(A)	Incorrect. TCP/IP does not specify a minimum transmission speed for Internet communications.
(B)	Incorrect. Internet communications are not designed to be completely secure.
(C)	**Correct.** Protocols for Internet communication, such as TCP/IP, are intended to define a standard format for messages sent between devices on the Internet.
(D)	Incorrect. The ownership of encryption keys is validated by certificate authorities, not by TCP/IP.

Question 64

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	4.2.4B 4.2.4C

(A)	Incorrect. For this set of inputs, the `IF` condition `x = y` evaluates to `false`, so the body of the `ELSE` statement is executed. The expression `y = z` evaluates to `false`, so `false` is returned as intended.
(B)	Incorrect. For this set of inputs, the `IF` condition `x = y` evaluates to `true`, so the body of the `IF` statement is executed, returning `true` as intended.
(C)	**Correct.** For this set of inputs, `false` is returned even though two of the inputs are equal in value. The `IF` condition `x = y` evaluates to `false`, so the body of the `ELSE` statement is executed. The expression `y = z` evaluates to `false`, so `false` is returned.
(D)	Incorrect. For this set of inputs, the `IF` condition `x = y` evaluates to `false`, so the body of the `ELSE` statement is executed. The expression `y = z` evaluates to `true`, so `true` is returned as intended.

Question 65

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.3 Computing has global effects—both beneficial and harmful—on people and society.	7.3.1 Analyze the beneficial and harmful effects of computing.	P4 Analyzing problems and artifacts	7.3.1Q

(A)	Incorrect. Open-source software is typically free or low-cost.
(B)	Incorrect. Open-source software allows developers to customize the source code to their needs.
(C)	**Correct.** Open-source software has source code that is released under a license that allows users the rights to use and distribute it. However, there is no guarantee that the original developer of open-source software will provide support for its users.
(D)	Incorrect. Open-source software can be continually updated without the original developers once it becomes available to the public.

Question 66

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	5.3.1 Use abstraction to manage complexity in programs.	P3 Abstracting	5.3.1A 5.3.1B 5.3.1C 5.3.1D 5.3.1E 5.3.1K 5.3.1L

(A)	Incorrect. For example, assume that `list1` contains `[10, 10, 20, 30, 40, 50, 60]` and `list2` contains `[20, 20, 40, 60, 80]`. The first line of code creates `bothList`, which contains `[10, 10, 20, 30, 40, 50, 60, 20, 20, 40, 60, 80]`. The second line of code creates `uniqueList`, which contains `[10, 20, 30, 40, 50, 60, 80]`. The third line of code assigns to `count` the length of `bothList` (12) minus the length of `bothList` (7), producing the incorrect result `5`.
(B)	Incorrect. For example, assume that `list1` contains `[10, 10, 20, 30, 40, 50, 60]` and `list2` contains `[20, 20, 40, 60, 80]`. The first line of code creates `newList1`, which contains `[10, 20, 30, 40, 50, 60]`. The second line of code creates `newList2`, which contains `[20, 40, 60, 80]`. The third line of code creates `bothList`, which contains `[10, 20, 30, 40, 50, 60, 20, 40, 60, 80]`. The fourth line of code assigns to `count` the length of `list1` (7) plus the length of `list2` (5) minus the length of `bothList` (10), producing the incorrect result `2`.
(C)	Incorrect. For example, assume that `list1` contains `[10, 10, 20, 30, 40, 50, 60]` and `list2` contains `[20, 20, 40, 60, 80]`. The first line of code creates `newList1`, which contains `[10, 20, 30, 40, 50, 60]`. The second line of code creates `newList2`, which contains `[20, 40, 60, 80]`. The third line of code creates `bothList`, which contains `[10, 20, 30, 40, 50, 60, 20, 40, 60, 80]`. The fourth line of code assigns to `count` the length of `newList1` (6) plus the length of `newList2` (4) minus the length of `bothList` (10), producing the incorrect result `0`.

Question 66 (continued)

(D)	**Correct.** This code segment creates `newList1`, containing the unique elements from `list1`, and `newList2`, containing the unique elements from `list2`. These two lists are combined to form `bothList`. Any elements that appear in both lists are removed from `bothList` to form `uniqueList`. The correct count is the difference between the lengths of `bothList` and `uniqueList`. For example, assume that `list1` contains `[10, 10, 20, 30, 40, 50, 60]` and `list2` contains `[20, 20, 40, 60, 80]`. The first line of code creates `newList1`, which contains `[10, 20, 30, 40, 50, 60]`. The second line of code creates `newList2`, which contains `[20, 40, 60, 80]`. The third line of code creates `bothList`, which contains `[10, 20, 30, 40, 50, 60, 20, 40, 60, 80]`. The fourth line of code creates `uniqueList`, which contains `[10, 20, 30, 40, 50, 60, 80]`. Since `bothList` contains 10 elements and `uniqueList` contains 7 elements, the correct result `3` is assigned to `count`.

Question 131

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.	7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts.	P1 Connecting computing	7.4.1A 7.4.1B 7.4.1C 7.4.1D 7.4.1E

(A)	Incorrect. By developing new technologies for only advanced users, some beginning users with less digital literacy may not be successful with the technology.
(B)	**Correct.** Providing accessibility features may allow some groups to access technology and content that they previously could not access.
(C)	Incorrect. Limiting access to Web content is unlikely to provide equity of access to digital technologies.
(D)	**Correct.** Some geographic locations lack the network infrastructure necessary to provide digital connectivity. Investing in network infrastructure is likely to provide people in remote locations access that they previously did not have.

Question 132

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts.	5.5.1 Employ appropriate mathematical and logical concepts in programming.	P1 Connecting computing	5.5.1E 5.5.1F

(A)	**Correct.** Since `x` is `true`, the body of the `IF` statement is executed. Since `x OR y` evaluates to `true`, `true` is displayed.
(B)	**Correct.** Since `x OR y` evaluates to `true`, the body of the `IF` statement is executed. Since `x` is `true`, `true` is displayed.
(C)	Incorrect. Since `x OR y` evaluates to `true`, the body of the `IF` statement is executed. Since `x AND y` evaluates to `false`, `false` is displayed.
(D)	Incorrect. Since `x AND y` evaluates to `false`, the body of the `IF` statement is not executed, and nothing is displayed.

Question 133

Enduring Understanding	Learning Objective	Computational Thinking Practice	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, patterns, or trends.	P4 Analyzing problems and artifacts	3.2.1A 3.2.1B 3.2.1E

(A)	**Correct.** In order to perform the desired calculation, the selling price, the genre, and the quantity available are needed. The author is not needed.
(B)	**Correct.** In order to perform the desired calculation, the selling price, the genre, and the quantity available are needed. The title is not needed.
(C)	Incorrect. The genre is needed to perform the desired calculation. All books that are not in the specified genre should be filtered out.
(D)	Incorrect. The quantity available is needed to perform the desired calculation. The quantity available for each book is multiplied by its selling price to determine the total amount of money received for selling all copies of the book.

Question 134

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	4.2.4B 4.2.4C

(A)	Incorrect. For these values, the procedure repeatedly adds `2` to `result` five times, resulting in the intended product `10`.
(B)	**Correct.** Since `y` is initially negative, the loop condition `count ≥ y` is initially `true`, so the body of the loop is never executed and `0` is returned.
(C)	Incorrect. For these values, the procedure repeatedly adds `-2` to `result` five times, resulting in the intended product `-10`.
(D)	**Correct.** Since `y` is initially negative, the loop condition `count ≥ y` is initially `true`, so the body of the loop is never executed and `0` is returned.

Question 135

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions.	5.3.1 Use abstraction to manage complexity in programs.	P3 Abstracting	5.3.1D 5.3.1I

(A)	Incorrect. This code segment stores the substring `"lope"` in `animal`. It then concatenates `"lope"` and `"a"`, storing the result `"lopea"` in `animal`. Lastly, it concatenates the substring `"jack"` and `"lopea"`, storing the result `"jacklopea"` in `animal`.
(B)	**Correct.** This code segment stores the substring `"lope"` in `animal`. It then concatenates `"a"` and `"lope"`, storing the result `"alope"` in `animal`. Lastly, it concatenates the substring `"jack"` and `"alope"`, storing the result `"jackalope"` in `animal`.
(C)	**Correct.** This code segment stores the substring `"jack"` in `animal`. It then concatenates `"jack"` and `"a"`, storing the result `"jacka"` in `animal`. Lastly, it concatenates `"jacka"` and the substring `"lope"`, storing the result `"jackalope"` in `animal`.
(D)	Incorrect. This code segment stores the substring `"jack"` in `animal`. It then concatenates `"jack"` and `"a"`, storing the result `"jacka"` in `animal`. Lastly, it concatenates the substring `"lope"` and `"jacka"`, storing the result `"lopejacka"` in `animal`.

Question 136

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Connecting computing	6.3.1D 6.3.1E 6.3.1F

(A)	**Correct.** A distributed denial-of-service (DDoS) attack compromises a target by flooding it with requests from multiple systems. This particular attack attempts to disrupt service to a Web store.
(B)	Incorrect. This is an example of a phishing attempt.
(C)	**Correct.** A distributed denial-of-service (DDoS) attack compromises a target by flooding it with requests from multiple systems. This particular attack attempts to disrupt service to a donation site.
(D)	Incorrect. This attack attempts to trick receivers to click links to potentially malicious Web sites, but does not overwhelm the receivers in an attempt to disrupt service.

Question 137

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	5.4.1E 5.4.1F 5.4.1G

(A)	**Correct.** This line should be removed. The variable `count` should increase by `1` when `currentNum` is a perfect number, so it should only be incremented in the body of the `IF` statement.
(B)	Incorrect. This line should not be removed. The variable `count` should increase by `1` when `currentNum` is a perfect number, so it should be incremented in the body of the `IF` statement.
(C)	**Correct.** This line should be removed. Every integer from `start` to `end` should be checked, so `currentNum` should only be incremented inside the loop but outside the body of the `IF` statement.
(D)	Incorrect. This line should not be removed. Every integer from `start` to `end` should be checked, so `currentNum` should be incremented inside the loop but outside the body of the `IF` statement.

Question 138

Enduring Understanding	Learning Objective	Computational Thinking Practice	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 Analyzing problems and artifacts	4.2.4B 4.2.4C

(A)	**Correct.** For this code segment, `count` is increased to `1` the first time `"birch"` is encountered in the list. However, `count` is reset to `0` when the code segment moves to the next list element. The last time `"birch"` is encountered in the list, `count` is again increased to `1`, causing the procedure to return `1` instead of the intended result `2`.
(B)	**Correct.** For this code segment, `count` is increased to `1` the first time `"maple"` is encountered in the list. However, `count` is reset to `0` when the code segment moves to the next list element. This causes the procedure to return `0` instead of the intended result `1`.
(C)	Incorrect. For this code segment, `count` is increased to `1` when `"oak"` is encountered as the last element of the list. The loop then terminates and the procedure returns the intended result `1`.
(D)	Incorrect. For this code segment, `count` is initialized to `0`. Since `"spruce"` does not appear in the list, the procedure returns the intended result `0`.