For the 2020 Exam

AP® CollegeBoard

AP® Computer Science Principles

Practice Exam and Notes

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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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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: `a ← expression`	Evaluates `expression` and assigns the result to the variable `a`.

Text:
`DISPLAY (expression)`
 	
Block:
`DISPLAY expression`
	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:
`RANDOM a, b`
	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: `NOT condition`	Evaluates to `true` if condition is `false`; otherwise evaluates to `false`.
Text: `condition1 AND condition2` Block: `condition1 AND condition2`	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:
`REPEAT UNTIL condition`
`block of statements`
	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:
`list i`
	Refers to the element of `list` at index `i`. The first element of `list` is at index `1`.

Text:
`list[i] ← list[j]`
 	
Block:
`list i ← list j`
	Assigns the value of `list[j]` to `list[i]`.

Text:
`list ← [value1, value2, value3]`
 	
Block:
`list ← value1, value2, value3`
	Assigns `value1`, `value2`, and `value3` to `list[1]`, `list[2]`, and `list[3]`, respectively.

Text:
`FOR EACH item IN list`
`{`
`  <block of statements>`
`}`
 	
Block:
`FOR EACH item IN list`
`block of statements`
	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`.

REFERENCE MATERIALS

Instruction	Explanation
List Operations (continued)	
Text: `INSERT (list, i, value)` Block: `INSERT` [`list, i, value`]	Any values in `list` at indices greater than or equal to `i` are shifted to the right. The length of list is increased by 1, and `value` is placed at index `i` in `list`.
Text: `APPEND (list, value)` Block: `APPEND` [`list, value`]	The length of `list` is increased by 1, and `value` is placed at the end of `list`.
Text: `REMOVE (list, i)` Block: `REMOVE` [`list, i`]	Removes the item at index `i` in `list` and shifts to the left any values at indices greater than `i`. The length of `list` is decreased by 1.
Text: `LENGTH (list)` Block: `LENGTH` [`list`]	Evaluates to the number of elements in `list`.
Procedures	

Text:
`PROCEDURE name (parameter1,`
`parameter2, ...)`
`{`
`<instructions>`
`}`
 	
Block:
`PROCEDURE name` [`parameter1, parameter2,...`]
[`instructions`]
	A procedure, `name`, takes zero or more parameters. The procedure contains programming instructions.

Text:
`PROCEDURE name (parameter1,`
`parameter2, ...)`
`{`
`<instructions>`
`RETURN (expression)`
`}`
 	
Block:
`PROCEDURE name` [`parameter1, parameter2,...`]
[`instructions`]
`RETURN` [`expression`]
	A procedure, `name`, takes zero or more parameters. The procedure contains programming instructions and returns the value of `expression`. The `RETURN` statement may appear at any point inside the procedure and causes an immediate return from the procedure back to the calling program.

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.

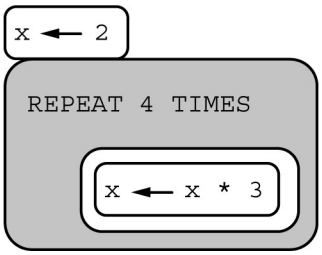
Text:
`ROTATE_LEFT ()`
 	
Block:
`ROTATE_LEFT`
	The robot rotates in place 90 degrees counterclockwise (i.e., makes an in-place left turn).

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)

```
REPEAT 2 TIMES
    REPEAT 3 TIMES
        DISPLAY "red"
    DISPLAY "blue"
```

(B)

```
REPEAT 2 TIMES
    REPEAT 3 TIMES
        DISPLAY "blue"
    DISPLAY "red"
```

(C)

```
REPEAT 3 TIMES
    REPEAT 2 TIMES
        DISPLAY "red"
    DISPLAY "blue"
```

(D)

```
REPEAT 3 TIMES
    REPEAT 2 TIMES
        DISPLAY "blue"
    DISPLAY "red"
```

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.

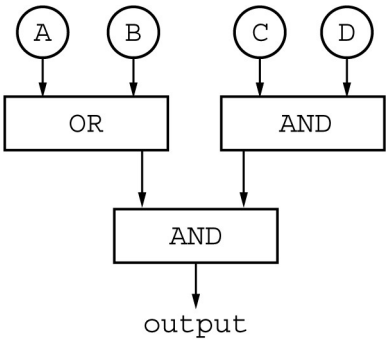
   (B) The precision of the result is limited due to the constraints of using a floating-point representation.

   (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.

GO ON TO THE NEXT PAGE.

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`

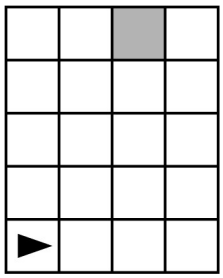
(B) `A = true, B = false, C = false, D = true`

(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:

```
REPEAT 2 TIMES
    MOVE_FORWARD
    ROTATE_LEFT
    MOVE_FORWARD
    MOVE_FORWARD
    ROTATE_RIGHT
```

Program II:

```
REPEAT UNTIL GoalReached
    IF CAN_MOVE forward
        MOVE_FORWARD
    ELSE
        ROTATE_LEFT
```

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.

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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

GO ON TO THE NEXT PAGE.

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

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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

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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`.

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17. Consider the two programs below.

Program A:

```
i ← 1
REPEAT UNTIL (i > 10)
    DISPLAY [i]
    i ← i + 1
```

Program B:

```
i ← 0
REPEAT UNTIL (i ≥ 10)
    i ← i + 1
    DISPLAY [i]
```

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

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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

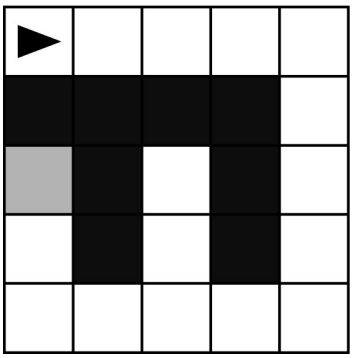
(B) III only

(C) I and II only

(D) I, II, and III

GO ON TO THE NEXT PAGE.

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 ()
```

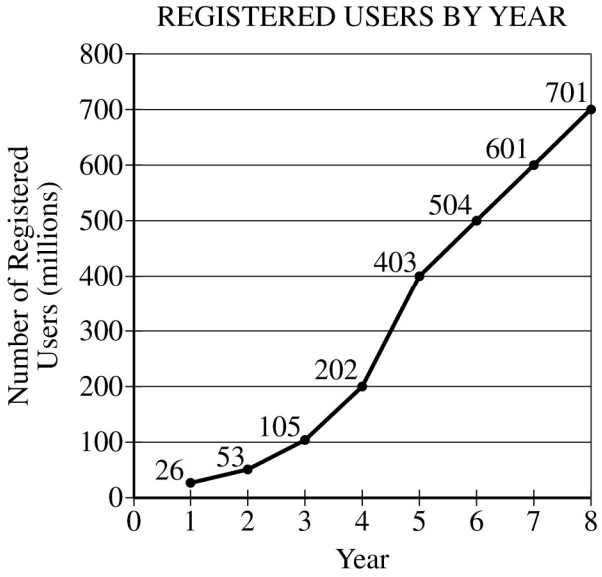
GO ON TO THE NEXT PAGE.

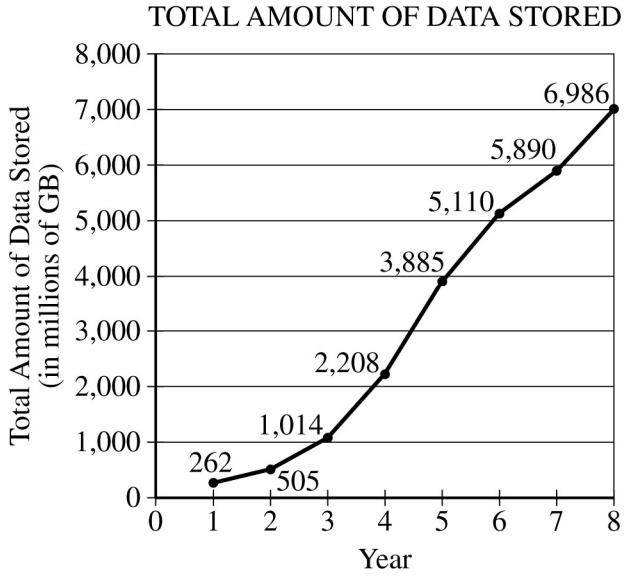
NO TEST MATERIAL ON THIS PAGE

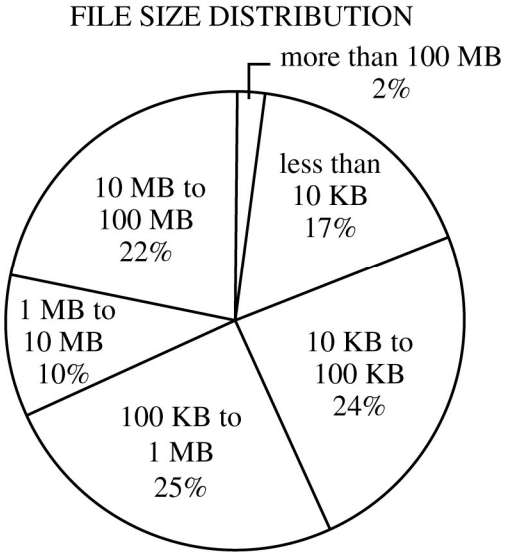
GO ON TO THE NEXT PAGE.

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.







(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.

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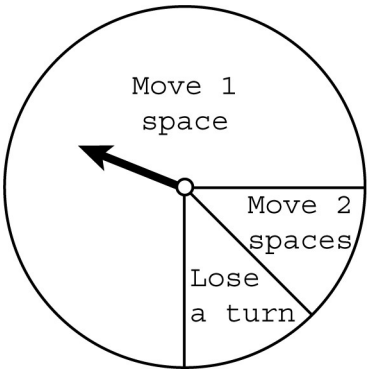
25. Consider the following spinner, which is used to determine how pieces are to be moved on a game board. The region labeled `"Move 1 space"` is six times as large as each of the other two regions.



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)

```
spin ← RANDOM 1, 8
IF spin = 1
    DISPLAY "Move 1 space"
ELSE
    IF spin = 2
        DISPLAY "Move 2 spaces"
    ELSE
        DISPLAY "Lose a turn"
```

(D)

```
spin ← RANDOM 1, 8
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.

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

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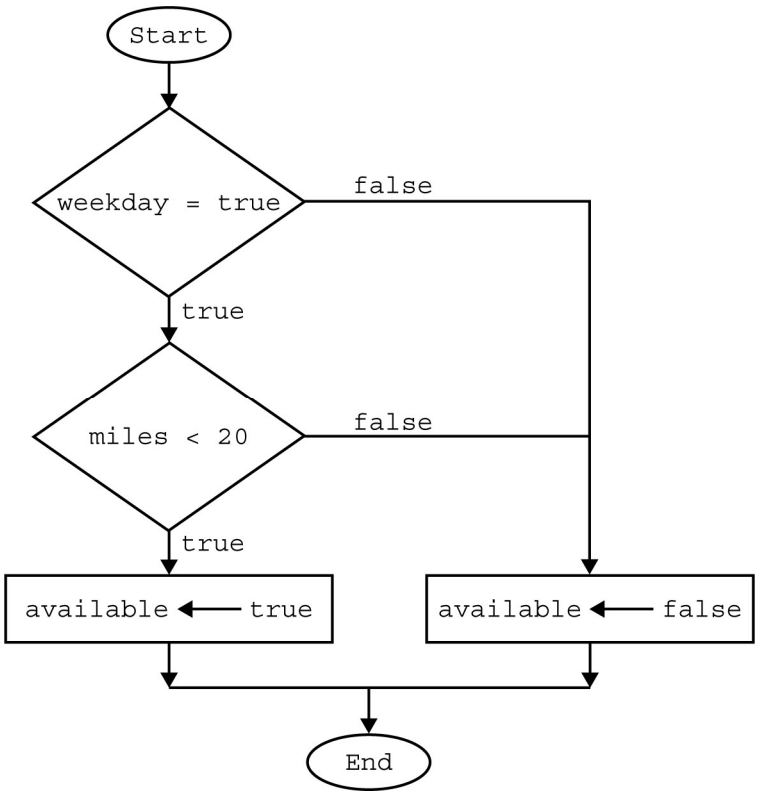

Which of the following statements is equivalent to the algorithm in the flowchart?

(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.

```
val ← 0
sum ← 0
REPEAT 10 TIMES
    val ← val + 2
    sum ← sum + val
DISPLAY sum
```

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

GO ON TO THE NEXT PAGE.

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

GO ON TO THE NEXT PAGE.

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.

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35. In the following program, assume that the variable n has been initialized with an integer value.

```
IF (n ≥ 0)
    [n ← n + 1]
ELSE
    [n ← n * -1]
IF (n ≥ 1)
    IF (n ≥ 30)
        [DISPLAY "too high"]
    ELSE
        IF (n ≥ 10)
            [DISPLAY "in range"]
        ELSE
            [DISPLAY "too low"]
ELSE
    [DISPLAY "out of range"]
```

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

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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)
```

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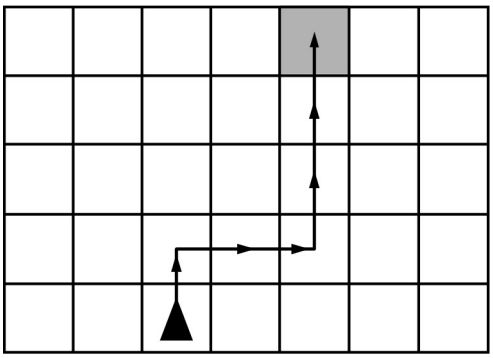
39. The following question uses a robot in a grid of squares. The robot is represented by a triangle, which is initially facing toward the top of the grid.



Consider the procedure below.

```
PROCEDURE BotMover [x]
    MOVE_FORWARD
    REPEAT x TIMES
        ROTATE_RIGHT
    MOVE_FORWARD
```

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

(A)
```
BotMover [1]
BotMover [1]
BotMover [0]
```

(B)
```
BotMover [1]
BotMover [2]
BotMover [3]
```

(C)
```
BotMover [1]
BotMover [3]
BotMover [0]
```

(D)
```
BotMover [3]
BotMover [1]
BotMover [0]
```

GO ON TO THE NEXT PAGE.

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.

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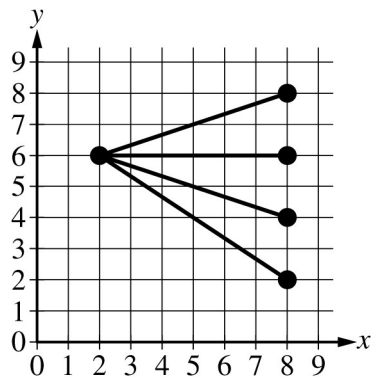
42. Consider the following procedure.

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.

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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

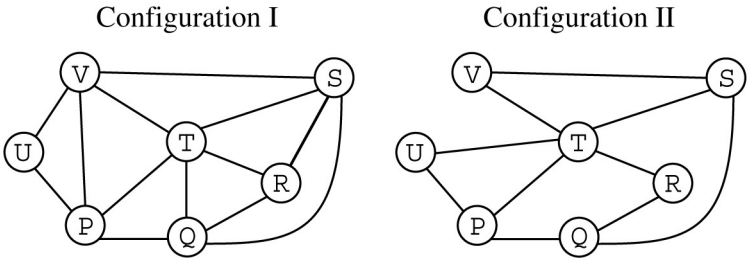
(C) To issue users a digital certificate to enable Internet communication

(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

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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)

```
flip ← RANDOM [0,3]
IF (flip = 3)
    DISPLAY ["You lose."]
ELSE
    DISPLAY ["You win!"]
```

(B)

```
flip ← RANDOM [0,3]
IF (flip = 3) OR (flip = 0)
    DISPLAY ["You win!"]
ELSE
    DISPLAY ["You lose."]
```

(C)

```
sum ← 0
REPEAT 3 TIMES
    sum ← sum + RANDOM [0,1]
IF (sum = 3)
    DISPLAY ["You win!"]
ELSE
    DISPLAY ["You lose."]
```

(D)

```
sum ← 0
REPEAT 3 TIMES
    sum ← sum + RANDOM [0,1]
IF (sum = 3) OR (sum = 0)
    DISPLAY ["You win!"]
ELSE
    DISPLAY ["You lose"]
```

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`.

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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

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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

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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.

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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

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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

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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.

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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")`

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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.

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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

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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)

```
IF (x)
    DISPLAY (x OR y)
```

(B)

```
IF (x OR y)
    DISPLAY (x)
```

(C)

```
IF (x OR y)
    DISPLAY (x AND y)
```

(D)

```
IF (x AND y)
    DISPLAY (x OR y)
```

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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

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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.

```
PROCEDURE Multiply [x, y]
    count ← 0
    result ← 0
    REPEAT UNTIL (count ≥ y)
        result ← result + x
        count ← count + 1
    RETURN [result]
```

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]`

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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 two 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)
```

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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.

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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.