CollegeBoard

AP® Computer Science Principles
Practice Exam and Notes

Important Note

This Practice Exam is provided by the College Board for AP Exam preparation. Teachers are permitted to download the materials and make copies to use with their students in a classroom setting only. To maintain the security of this exam, teachers should collect all materials after their administration and keep them in a secure location.

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Effective Fall 2016

About the College Board

The College Board is a mission-driven not-for-profit organization that connects students to college success and opportunity. Founded in 1900, the College Board was created to expand access to higher education. Today, the membership association is made up of over 6,000 of the world's leading educational institutions and is dedicated to promoting excellence and equity in education. Each year, the College Board helps more than seven million students prepare for a successful transition to college through programs and services in college readiness and college success — including the SAT® and the Advanced Placement Program®. The organization also serves the education community through research and advocacy on behalf of students, educators, and schools. For further information visit **www.collegeboard.org**.

AP® Equity and Access Policy

The College Board strongly encourages educators to make equitable access a guiding principle for their AP® programs by giving all willing and academically prepared students the opportunity to participate in AP. We encourage the elimination of barriers that restrict access to AP for students from ethnic, racial, and socioeconomic groups that have been traditionally underrepresented. Schools should make every effort to ensure their AP classes reflect the diversity of their student population. The College Board also believes that all students should have access to academically challenging course work before they enroll in AP classes, which can prepare them for AP success. It is only through a commitment to equitable preparation and access that true equity and excellence can be achieved.

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Introduction

Beginning in May 2017, the AP Computer Science Principles Exam will measure student achievement of the course learning objectives, assessing both the application of the computational thinking practices and an understanding of the big ideas. Exam questions may assess achievement of multiple learning objectives. They may also address content from more than one essential knowledge statement. Exam questions may be accompanied by nontextual stimulus material such as diagrams, charts, or other graphical illustrations. The exam will feature multiple-choice questions, presented as either single-select questions in which students will select one answer choice, or multiple-select questions in which students will be required to select two answer choices.

The AP Computer Science Principles assessment consists of two parts: completion of a through-course assessment and the end-of-course AP Exam. The through-course assessment consists of two performance tasks and is worth 40 percent of a student's AP score. The performance tasks require students to upload digital artifacts and written responses via a Web-based digital portal. The end-of-course exam is worth 60 percent of a student's AP score and consists of 74 multiple-choice questions. This practice exam is intended as preparation for the end-of-course exam only.

Part I of this publication is the AP Computer Science Principles Practice Exam. This will mirror the look and feel of an actual AP Exam, including instructions and sample questions. However, these exam items have never been administered in an operational exam, and, therefore, statistical analysis is **not** available. The purpose of this section is to provide educators with sample exam questions that accurately reflect the composition/design of the exam and to offer these questions in a way that gives teachers the opportunity to test their students in an exam situation that closely resembles the actual exam administration.

Part II is the Notes on the AP Computer Science Principles Practice Exam. This section offers an explanation of how each question in the practice exam links back to the curriculum framework in order to provide a clear link between curriculum and assessment. The multiple-choice rationales explain the correct and incorrect options.

How AP Courses and Exams Are Developed

AP courses and exams are designed by committees of college faculty and AP teachers who ensure that each AP course and exam reflects and assesses college-level expectations. These committees define the scope and expectations of the course, articulating through a curriculum framework what students should know and be able to do upon completion of the AP course. Their work is informed by data collected from a range of colleges and universities to ensure that AP course work reflects current scholarship and advances in the discipline.

These same committees are also responsible for designing and approving exam specifications and exam questions that clearly connect to the curriculum framework. The AP Exam development process is a multiyear endeavor; all AP Exams undergo extensive review, revision, piloting, and analysis to ensure that questions are high quality and fair and that the questions comprise an appropriate range of difficulty.

Throughout AP course and exam development, the College Board gathers feedback from secondary and postsecondary educators. This feedback is carefully considered to ensure that AP courses and exams provide students with a college-level learning experience and the opportunity to demonstrate their qualifications for advanced placement and college credit upon college entrance.

Methodology Guiding Course and Exam Development

The course and the exam are conceived and developed using similar methodologies. The course is designed using the principles from *Understanding by Design*, and the exam is designed and developed using the similarly principled evidence-centered design approach. Both processes begin by identifying the end goals that identify what students should know and be able to do by the end of their AP experience. These statements about students' knowledge and abilities, along with descriptions of the observable evidence that delineate levels of student performance, serve simultaneously as the learning objectives for the course and the targets of measurement for the exam. The course and exam, by design, share the same foundation.

Course Development

Each committee first articulates its discipline's high-level goals before identifying the course's specific learning objectives. This approach is consistent with "backward design" — the practice of developing curricula, instruction, and assessments with the end goal in mind. The learning objectives describe what students should know and be able to do, thereby providing clear instructional goals as well as targets of measurement for the exam.

Exam Development

Exam development begins with the committee making decisions about the overall nature of the exam. How will the learning objectives for the course be assessed? How will the course content and skills be distributed across the exam? How many multiple-choice questions should there be? How much time will be given to complete the exam? Answers to these questions become part of the exam specifications.

With the exam specifications set, assessment specialists design questions that conform to these specifications. The committee reviews every exam question for alignment with the curriculum framework, accuracy, and a number of other criteria that ensure the integrity of the exam.

Exam questions are then piloted in AP classrooms to determine their statistical properties. Questions that have been approved by the committee and piloted successfully are included in an exam. When an exam is assembled, the committee conducts a final review to ensure overall conformity with the specifications.

How AP Exams Are Scored

The exam scoring process, like the course and exam development process, relies on the expertise of both AP teachers and college faculty. While multiple-choice questions are scored by machine, the through-course performance assessments are scored by college faculty and expert AP teachers at the annual AP Reading.

AP Exam Readers are thoroughly trained, and their work is monitored throughout the Reading for fairness and consistency. In each subject, a highly respected college faculty member fills the role of Chief Reader, who, with the help of AP Readers in leadership positions, maintains the accuracy of the scoring standards. Scores on the performance assessments are weighted and combined with the weighted results of the computer-scored multiple-choice questions and this composite score is converted into an AP Exam score of 5, 4, 3, 2, or 1.

The score-setting process is both precise and labor intensive, involving numerous psychometric analyses of the results of a specific AP Exam in a specific year and of the particular group of students who took that exam. Additionally, to ensure alignment with college-level standards, part of the score-setting process involves comparing the performance of AP students with the performance of students enrolled in comparable courses in colleges throughout the United States. In general, the AP composite score points are set so that the lowest raw score needed to earn an AP score of 5 is equivalent to the average score among college students earning grades of A in the college course. Similarly, AP Exam scores of 4 are equivalent to college grades of A–, B+, and B. AP Exam scores of 3 are equivalent to college grades of B–, C+, and C.

Using and Interpreting AP Scores

The extensive work done by college faculty and AP teachers in the development of the course and the exam and throughout the scoring process ensures that AP Exam scores accurately represent students' achievement in the equivalent college course. While colleges and universities are responsible for setting their own credit and placement policies, AP scores signify how qualified students are to receive college credit and placement:

AP Score	Recommendation
5	Extremely well qualified
4	Well qualified
3	Qualified
2	Possibly qualified
1	No recommendation

Additional Resources

Visit apcentral.collegeboard.org for more information about the AP Program.

Practice Exam

Exam Content and Format

The 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.

When you are ready to begin the exam, say:

> **You will be given 2 hours to answer 74 multiple-choice questions. Each question has four answer choices.**
>
> - **For question numbers 1 through 66, mark only the single best answer to each question.**
> - **For the remaining questions, numbered 67 through 74, 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	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
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28	
29	
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No.	Answer
31	
32	
33	
34	
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38	
39	
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41	
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53	
54	
55	
56	
57	
58	
59	
60	

No.	Answer
61	
62	
63	
64	
65	
66	

67		
68		
69		
70		
71		
72		
73		
74		

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

Exam reference materials are located at the front of this booklet.

This exam contains 74 multiple-choice 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. After you have decided which of the choices is best, fill in the appropriate letter in the corresponding space on the answer sheet.

For questions 67 through 74, select the two best answer choices for each question. After you have decided which two of the choices are best, enter both letters in the corresponding space on the answer sheet.

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 exam 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

Number of Questions—74

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

GO ON TO THE NEXT PAGE.

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.

REFERENCE MATERIALS

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 appropriate letter in the corresponding space on the answer sheet.

1. Consider the following code segment, which uses the variables `r`, `s`, and `t`.

```
r ← 1
s ← 2
t ← 3
r ← s
s ← t
DISPLAY (r)
DISPLAY (s)
```

What is displayed as a result of running the code segment?

(A) `1 1`

(B) `1 2`

(C) `2 3`

(D) `3 2`

---

2. Which of the following is a true statement about program documentation?

(A) Program documentation should not be changed after it is first written.

(B) Program documentation is only needed for programs in development; it is not needed after a program is completed.

(C) Program documentation is useful when programmers collaborate but not when a programmer works individually on a project.

(D) Program documentation is useful during initial program development and also when modifications are made to existing programs.

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3. Which of the following best explains what happens when a new device is connected to the Internet?

(A) A device driver is assigned to the device.

(B) An Internet Protocol (IP) address is assigned to the device.

(C) A packet number is assigned to the device.

(D) A Web site is assigned to the device.

---

4. Consider the following code segment.

```
j ← 1
REPEAT UNTIL <MISSING CONDITION>
    j ← j + 2
```

Which of the following replacements for `<MISSING CONDITION>` will result in an infinite loop?

(A) `j = 6`

(B) `j ≥ 6`

(C) `j = 7`

(D) `j > 7`

GO ON TO THE NEXT PAGE.

5. The algorithm below is used to simulate the results of flipping a coin 4 times. Consider the goal of determining whether the simulation resulted in an equal number of heads and tails.

Step 1 : Initialize the variables `heads_counter` and `flip_counter` to 0.

Step 2 : A variable `coin_flip` is randomly assigned a value of either 0 or 1.
If `coin_flip` has the value 0, the coin flip result is heads,
so `heads_counter` is incremented by 1.

Step 3 : Increment the value of `flip_counter` by 1.

Step 4 : Repeat steps 2 and 3 until `flip_counter` equals 4.

Following execution of the algorithm, which of the following expressions indicates that the simulation resulted in an equal number of heads and tails?

(A) `coin_flip = 1`

(B) `flip_counter = 1`

(C) `flip_counter = 2`

(D) `heads_counter = 2`

---

6. An algorithm has been developed to compute the sum of all the elements in a list of integers. Which of the following programming structures must be added to the existing algorithm so that the new algorithm computes the sum of only the even integers in the list?

(A) Iteration

(B) Searching

(C) Selection

(D) Sequencing

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7. Which of the following activities poses the greatest personal cybersecurity risk?

(A) Making a purchase at an online store that uses public key encryption to transmit credit card information

(B) Paying a bill using a secure electronic payment system

(C) Reserving a hotel room by e-mailing a credit card number to a hotel

(D) Withdrawing money from a bank account using an automated teller machine (ATM)

---

8. The code segment below uses the procedure `IsFound (list, item)`, which returns `true` if `item` appears in `list` and returns `false` otherwise. The list `resultList` is initially empty.

```
FOR EACH item IN inputList1
{
   IF (IsFound (inputList2, item)
   {
      APPEND (resultList, item)
   }
}
```

Which of the following best describes the contents of `resultList` after the code segment is executed?

(A) All elements in `inputList1` followed by all elements in `inputList2`

(B) Only elements that appear in both `inputList1` and `inputList2`

(C) Only elements that appear in either `inputList1` or `inputList2` but not in both lists

(D) Only elements that appear in `inputList1` but not in `inputList2`

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9. A programmer is writing a program that is intended to be able to process large amounts of data. Which of the following considerations is LEAST likely to affect the ability of the program to process larger data sets?

(A) How long the program takes to run

(B) How many programming statements the program contains

(C) How much memory the program requires as it runs

(D) How much storage space the program requires as it runs

---

10. Which of the following is LEAST likely to indicate a phishing attack?

(A) An e-mail from your bank asks you to call the number on your card to verify a transaction

(B) An e-mail from a merchant asks that you click on a link to reset your password

(C) An e-mail from a utility company asks you to enter your date of birth and social security number for verification purposes

(D) An e-mail indicates that you have won a large sum of money and asks you to enter your bank account number so that the money can be transferred to you

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11. Which of the following is considered an unethical use of computer resources?

(A) Downloading freeware or shareware onto your home computer

(B) Purchasing a game from an app store and downloading it directly to a mobile device

(C) Purchasing a single-user copy of photo editing software and installing it on all the computers in a computer lab

(D) Searching online for an electronic version of a school textbook

---

12. Which of the following statements are true about using a high-level programming language instead of a lower-level language?

I. Programs written in a high-level language are generally easier for people to read than programs written in a low-level language.

II. A high-level language provides programmers with more abstractions than a low-level language.

III. Programs written in a high-level language are generally easier to debug than programs written in a low-level language.

(A) I only

(B) I and III only

(C) II and III only

(D) I, II, and III

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13. A student is recording a song on her computer. When the recording is finished, she saves a copy on her computer. The student notices that the saved copy is of lower sound quality than the original recording. Which of the following could be a possible explanation for the difference in sound quality?

(A) The song was saved using fewer bits per second than the original song.

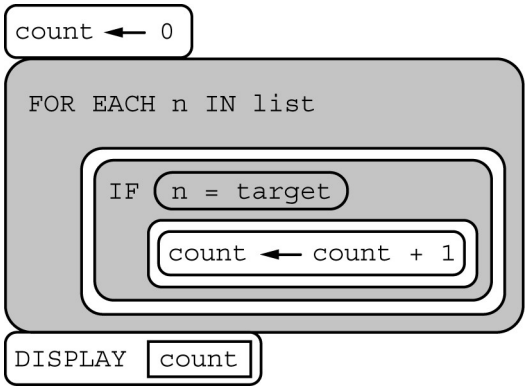
(B) The song was saved using more bits per second than the original song.

(C) The song was saved using a lossless compression technique.

(D) Some information is lost every time a file is saved from one location on a computer to another location.

---

14. Consider the following program, which is intended to display the number of times a number `target` appears in a list.



Which of the following best describes the behavior of the program?

(A) The program correctly displays the number of times `target` appears in the list.

(B) The program does not work as intended when `target` does not appear in the list.

(C) The program does not work as intended when `target` appears in the list more than once.

(D) The program does not work as intended when `target` appears as the last element of the list.

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15. In the program below, the initial value of `x` is 5 and the initial value of `y` is 10.

```
IF (x < 0)
{
   DISPLAY ("Foxtrot")
}
ELSE
{
   IF (x > y)
   {
      DISPLAY ("Hotel")
   }
   ELSE
   {
      IF (y > 0)
      {
         DISPLAY ("November")
      }
      ELSE
      {
         DISPLAY ("Yankee")
      }
   }
}
```

What is displayed as a result of running the program?

(A) `Foxtrot`

(B) `Hotel`

(C) `November`

(D) `Yankee`

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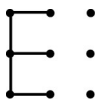
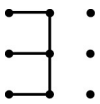
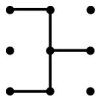
16. The procedure `Draw (length, direction)` is used to draw a line segment `length` units long in a given `direction` (left, right, up, or down), starting at the current cursor position. The cursor is then repositioned at the end of the line segment that was drawn. Consider the following program, where the cursor starts in the upper left corner of a grid of dots. The dots are spaced one unit apart.

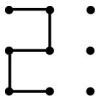
```
Draw (1, right)
Draw (2, down)
Draw (1, left)
Draw (1, right)
Draw (1, up)
Draw (1, left)
```

Which of the following represents the figure that is drawn by the program?

(A) 

(B) 

(C) 

(D) 

---

17. Central High School keeps a database of information about each student, including the numeric variables `numberOfAbsences` and `gradePointAverage`. The expression below is used to determine whether a student is eligible to receive an academic award.

```
(numberOfAbsences ≤ 5) AND (gradePointAverage > 3.5)
```

Which of the following pairs of values indicates that a student is eligible to receive an academic award?

(A) `numberOfAbsences = 3, gradePointAverage = 3.5`

(B) `numberOfAbsences = 5, gradePointAverage = 3.8`

(C) `numberOfAbsences = 6, gradePointAverage = 3.4`

(D) `numberOfAbsences = 6, gradePointAverage = 3.6`

GO ON TO THE NEXT PAGE.

18. Computers are often used to search through large sets of data to find useful patterns in the data. Which of the following tasks is NOT an example where searching for patterns is needed to produce useful information?

(A) A credit card company analyzing credit card purchases to identify potential fraudulent charges

(B) A grocery store analyzing customers' past purchases to suggest new products the customer may be interested in

(C) A high school analyzing student grades to identify the students with the top ten highest grade point averages

(D) An online retailer analyzing customers' viewing habits to suggest other products based on the purchasing history of other customers

---

19. The code fragment below is intended to display `"odd"` if the positive number `num` is odd.

```
IF <MISSING CONDITION>
    DISPLAY "odd"
```

Which of the following can be used to replace `<MISSING CONDITION>` so that the code fragment will work as intended?

(A) `(num MOD 1) = 0`

(B) `(num MOD 1) = 1`

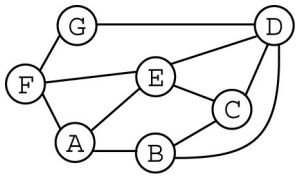
(C) `(num MOD 2) = 0`

(D) `(num MOD 2) = 1`

GO ON TO THE NEXT PAGE.

Questions 20 - 21 refer to the information below.

The figure below represents a network of physically linked computers labeled A through G. A line between two computers indicates that the computers can communicate directly with each other. Any information sent between two computers that are not directly connected must go through at least one other computer. For example, information can be sent directly between computers A and B, but information sent between computers A and C must go through other computers.



20. What is the minimum number of connections that must be broken or removed in the network before computer E can no longer communicate with computer F?

(A) 1

(B) 2

(C) 3

(D) 4

---

21. Which of the following statements about security in the network is true?

I. Computers A and D need to communicate with at least two additional computers in the network in order to communicate with each other.

II. Computers B and C can communicate with each other without additional computers being aware of the communication.

(A) I only

(B) II only

(C) I and II

(D) Neither I nor II

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22. ASCII is a character-encoding scheme that uses 7 bits to represent each character. The decimal (base 10) values 65 through 90 represent the capital letters A through Z, as shown in the table below.

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

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

What ASCII character is represented by the binary (base 2) number 1001010 ?

(A) H

(B) I

(C) J

(D) K

---

23. A user enters a Web address in a browser, and a request for a file is sent to a Web server. Which of the following best describes how the file is sent to the user?

(A) The file is broken into packets for transmission. The packets must be reassembled upon receipt.

(B) The file is broken into packets for transmission. The user's browser must request each packet in order until all packets are received.

(C) The server attempts to connect directly to the user's computer. If the connection is successful, the entire file is sent. If the connection is unsuccessful, an error message is sent to the user.

(D) The server repeatedly attempts to connect directly to the user's computer until a connection is made. Once the connection is made, the entire file is sent.

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24. Some programming languages use constants, which are variables that are initialized at the beginning of a program and never changed. Which of the following are good uses for a constant?

I. To represent the mathematical value π (pi) as 3.14

II. To represent the current score in a game

III. To represent a known value such as the number of days in a week

(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

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25. A cable television company stores information about movie purchases made by subscribers. Each day, the following information is summarized and stored in a publicly available database.

- The day and date each movie was purchased
- The title of each movie purchased
- The cities where subscribers purchased each movie
- The number of times each movie was purchased by subscribers in a given city

A sample portion of the database is shown below. The database is sorted by date and movie title.

Day and Date	Movie Title	City	Number of Times Purchased
Sat 01 / 05 / 2014	Movie A	Houston, Texas	1
Sat 01 / 05 / 2014	Movie A	Detroit, Michigan	2
Sat 01 / 05 / 2014	Movie B	Houston, Texas	1
Sat 01 / 05 / 2014	Movie C	Anchorage, Alaska	1
Sun 01 / 06 / 2014	Movie A	Wichita, Kansas	3

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

(A) The date when a certain movie was purchased the greatest number of times

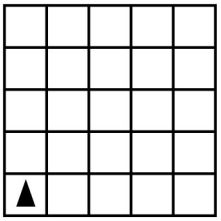
(B) The number of movies purchased by an individual subscriber for a particular month

(C) The total number of cities in which a certain movie was purchased

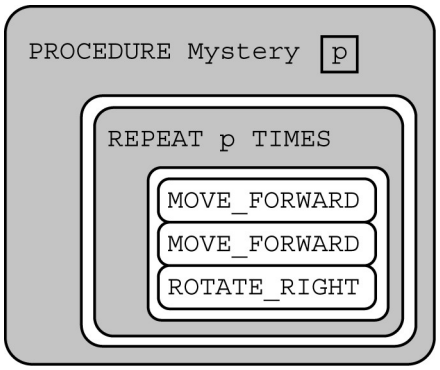
(D) The total number of movies purchased in a certain city during a particular month

GO ON TO THE NEXT PAGE.

26. 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 toward the top of the grid.

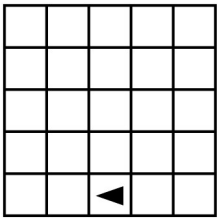


Code for the procedure `Mystery` is shown below. Assume that the parameter `p` has been assigned a positive integer value (e.g., 1, 2, 3, …).

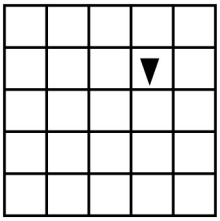


Which of the following shows a possible result of calling the procedure?

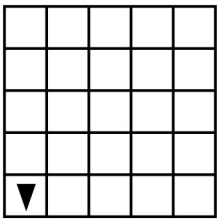
(A)



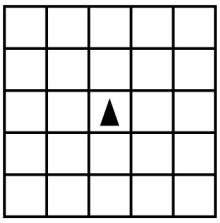
(B)



(C)



(D)



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27. A new bank plans to make customer convenience a priority by minimizing the amount of time a customer waits in line. The bank is considering two options: a single line where the customer at the front waits for the next available teller, or separate lines for each teller. The bank decides to use a computer simulation of these two options to determine the average wait time for customers.

Which of the following is NOT true about the bank's plan?

(A) The bank can incorporate other factors, such as the number of tellers, in the simulation.

(B) The bank can use the simulation to investigate these two options without causing inconvenience for customers.

(C) The bank may consider new alternatives based on the simulation results.

(D) The simulation will not produce usable results because actual customer data are not available.

---

28. Consider the code segment below.

```
Line 1:  IF (a = 0)
Line 2:  {
Line 3:     b ← a + 10
Line 4:  }
Line 5:  ELSE
Line 6:  {
Line 7:     b ← a + 20
Line 8:  }
```

Which of the following changes will NOT affect the results when the code segment is executed?

(A) Changing line 3 to `b ← 10`

(B) Changing line 3 to `a ← b + 10`

(C) Changing line 7 to `b ← 20`

(D) Changing line 7 to `a ← b + 20`

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29. A programmer wrote the program below. The program uses a list of numbers called `numList`. The program is intended to display the sum of the numbers in the list.

```
sum ← numList [1]

FOR EACH value IN numList
    sum ← sum + value

DISPLAY [sum]
```

In order to test the program, the programmer initializes `numList` to `[0, 1, 4, 5]`. The program displays `10`, and the programmer concludes that the program works as intended. Which of the following is true?

(A) The conclusion is correct; the program works as intended.

(B) The conclusion is incorrect; the program does not display the correct value for the test case `[0, 1, 4, 5]`.

(C) The conclusion is incorrect; using the test case `[0, 1, 4, 5]` is not sufficient to conclude the program is correct.

(D) The conclusion is incorrect; using the test case `[0, 1, 4, 5]` only confirms that the program works for lists in increasing order.

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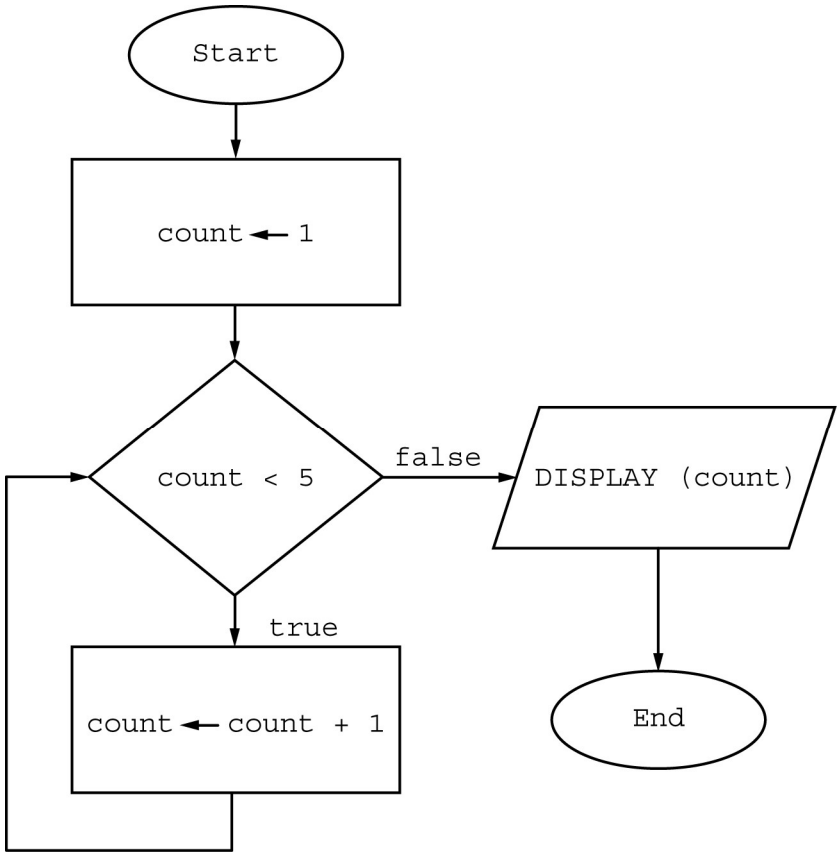
30. A flowchart is a way to visually represent an algorithm. The flowchart below uses the following building blocks.

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



What is displayed as a result of executing the algorithm in the flowchart?

(A) `5`

(B) `15`

(C) `1 2 3 4`

(D) `1 2 3 4 5`

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31. Two lists, `list1` and `list2`, contain the names of books found in two different collections. A librarian wants to create `newList`, which will contain the names of all books found in either list, in alphabetical order, with duplicate entries removed.

For example, if `list1` contains
`["Macbeth", "Frankenstein", "Jane Eyre"]`
and `list2` contains
`["Frankenstein", "Dracula", "Macbeth", "Hamlet"]`,
then `newList` will contain
`["Dracula", "Frankenstein", "Hamlet", "Jane Eyre", "Macbeth"]`.

The following procedures are available to create `newList`.

Procedure	Explanation
`Sort (list)`	Sorts `list` in alphabetical order and returns the resulting list.
`Combine (list1, list2)`	Creates a new list consisting of the entries from `list1` followed by the entries from `list2`. The resulting list is returned.
`RemoveDuplicates (list)`	Iterates through `list`. If any two or more entries have the same value, the duplicate entries are removed so that any entry appears at most once. The resulting list is returned.

Which of the following code segments will correctly create `newList`?

(A)
```
newList ← Combine (list1, list2)
newList ← Sort (newList)
newList ← RemoveDuplicates (newList)
```

(B)
```
list1 ← Sort (list1)
list2 ← Sort (list2)
newList ← Combine (list1, list2)
newList ← RemoveDuplicates (newList)
```

(C)
```
list1 ← RemoveDuplicates (list1)
list2 ← RemoveDuplicates (list2)
newList ← Combine (list1, list2)
newList ← Sort (newList)
```

(D)
```
list1 ← RemoveDuplicates (list1)
list1 ← Sort (list1)
list2 ← RemoveDuplicates (list2)
list2 ← Sort (list2)
newList ← Combine (list1, list2)
```

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32. An Internet service provider (ISP) is considering an update to its servers that would save copies of the Web pages most frequently visited by each user. Which of the following is LEAST likely to occur as a result of the update?

(A) Average response time for user requests might decrease.

(B) Privacy of users might be negatively affected.

(C) Storage requirements for the servers might increase.

(D) Web sites that are not visited frequently might no longer be accessible to users.

---

33. Which of the following is a characteristic of the fault-tolerant nature of routing on the Internet?

(A) The ability to use a hierarchical naming system to avoid naming conflicts

(B) The ability to provide data transmission even when some connections have failed

(C) The ability to resolve errors in domain name system (DNS) lookups

(D) The ability to use multiple protocols such as hypertext transfer protocol (HTTP), Internet protocol (IP), and simple mail transfer protocol (SMTP) to transfer data

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34. A car manufacturer uses simulation software during the design process for a new car. Which of the following are reasons to use simulation software in this context?

I. Using simulation software can save the company money by helping to compare designs early in the process, before prototype cars are built.

II. Using simulation software can help to identify safety issues by providing data about how different mechanical components will interact in a wide variety of situations.

III. The manufacturer can present simulation software to customers to demonstrate different design possibilities.

(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

---

35. Two computers are built by different manufacturers. One is running a Web server and the other is running a Web browser. Which of the following best describes the ability of the two computers to communicate with each other across the Internet?

(A) The computers cannot communicate because different manufacturers use different communication protocols.

(B) The computers can communicate, but additional hardware is needed to convert data packets from one computer's protocol to the other computer's protocol.

(C) The computers can communicate directly only if the messages consist of text; other formats cannot be interpreted across computers.

(D) The computers can communicate directly because Internet communication uses standard protocols.

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36. Programs I and II below are each intended to calculate the sum of the integers from 1 to `n`. Assume that `n` is a positive integer (e.g., 1, 2, 3, …).

Program I:

```
i ← 1
result ← 0
REPEAT n TIMES
    result ← result + i
    i ← i + 1
DISPLAY [result]
```

Program II:

```
i ← n
result ← 0
REPEAT n TIMES
    result ← result + i
    i ← i - 1
DISPLAY [result]
```

Which of the following best describes the behavior of the two programs?

(A) Program I displays the correct sum, but program II does not.

(B) Program II displays the correct sum, but program I does not.

(C) Both program I and program II display the correct sum.

(D) Neither program I nor program II displays the correct sum.

---

37. A large data set contains information about all students majoring in computer science in colleges across the United States. The data set contains the following information about each student.

- The student's gender
- The state in which the student attends college
- The student's grade point average on a 4.0 scale

Which of the following questions could be answered by analyzing only information in the data set?

(A) Do students majoring in computer science tend to have higher grade point averages than students majoring in other subjects?

(B) How many states have a higher percentage of female computer science majors than male computer science majors attending college in that state?

(C) What percent of students attending college in a certain state are majoring in computer science?

(D) Which college has the highest number of students majoring in computer science?

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38. Which of the following is a true statement about cloud computing?

(A) Cloud computing is convenient to implement but has a negative effect on the scalability of systems.

(B) Cloud computing is useful for large businesses but is not useful for individuals.

(C) Storing data using cloud computing can help ensure that data are not lost if a user's computer stops functioning.

(D) Storing data using cloud computing improves security over storing data on a personal computer.

---

39. Which of the following statements is true?

(A) Every problem can be solved with an algorithm for all possible inputs, in a reasonable amount of time, using a modern computer.

(B) Every problem can be solved with an algorithm for all possible inputs, but some will take more than 100 years, even with the fastest possible computer.

(C) Every problem can be solved with an algorithm for all possible inputs, but some of these algorithms have not been discovered yet.

(D) There exist problems that no algorithm will ever be able to solve for all possible inputs.

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40. Consider the following numbers.

- Binary 1100
- Decimal 11
- Hexadecimal D

Which of the following lists the numbers in order from least to greatest?

(A) Binary 1100, Decimal 11, Hexadecimal D

(B) Decimal 11, Binary 1100, Hexadecimal D

(C) Decimal 11, Hexadecimal D, Binary 1100

(D) Hexadecimal D, Decimal 11, Binary 1100

---

41. An algorithm will be used to identify the maximum value in a list of one or more integers. Consider the two versions of the algorithm below.

Algorithm I : Set the value of a variable `max` to -1. Iterate through the list of integer values. If a data value is greater than the value of the variable `max`, set `max` to the data value.

Algorithm II : Set the value of a variable `max` to the first data value. Iterate through the remaining values in the list of integers. If a data value is greater than the value of the variable `max`, set `max` to the data value.

Which of the following statements best describes the behavior of the two algorithms?

(A) Both algorithms work correctly on all input values.

(B) Algorithm I always works correctly, but Algorithm II only works correctly when the maximum value is not the first value in the list.

(C) Algorithm II always works correctly, but Algorithm I only works correctly when the maximum value is greater than or equal to -1.

(D) Neither algorithm will correctly identify the maximum value when the input contains both positive and negative input values.

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42. A search engine has a trend-tracking feature that provides information on how popular a search term is. The data can be filtered by geographic region, date, and category. Categories include arts and entertainment, computers and electronics, games, news, people and society, shopping, sports, and travel. Which of the following questions is LEAST likely to be answerable using the trends feature?

(A) In what month does a particular sport receive the most searches?

(B) In which political candidates are people interested?

(C) What is the cost of a certain electronics product?

(D) Which region of the country has the greatest number of people searching for opera performances?

---

43. A retailer that sells footwear maintains a single database containing records with the following information about each item for sale in the retailer's store.

- Item identification number
- Footwear type (sneakers, boots, sandals, etc.)
- Selling price (in dollars)
- Size
- Color
- Quantity available

Using only the database, which of the following can be determined?

(A) Which items listed in the database are not currently in the store

(B) Which colors are more popular among men than women

(C) Which type of footwear is most popular among adults

(D) The total number of shoes sold in a particular month

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44. Which of the following programs is most likely to benefit from the use of a heuristic?

(A) A program that calculates a student's grade based on the student's quiz and homework scores

(B) A program that encrypts a folder of digital files

(C) A program that finds the shortest driving route between two locations on a map

(D) A program that sorts a list of numbers in order from least to greatest

---

45. An author is considering publishing an e-book using a Creative Commons license. In which of the following situations would it be better for the author to use a Creative Commons license instead of a traditional copyright?

I. The author wants to make the e-book available as a free download.

II. The author wants to prevent people from sharing copies of the e-book on peer-to-peer networks.

III. The author wants to allow people permission to use and modify the e-book.

(A) I only

(B) II only

(C) I and III

(D) II and III

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46. A city government is attempting to reduce the digital divide between groups with differing access to computing and the Internet. Which of the following activities is LEAST likely to be effective in this purpose?

(A) Holding basic computer classes at community centers

(B) Providing free wireless Internet connections at locations in low-income neighborhoods

(C) Putting all government forms on the city Web site

(D) Requiring that every city school has computers that meet a minimum hardware and software standard

---

47. An online store uses 6-bit binary sequences to identify each unique item for sale. The store plans to increase the number of items it sells and is considering using 7-bit binary sequences. Which of the following best describes the result of using 7-bit sequences instead of 6-bit sequences?

(A) 2 more items can be uniquely identified.

(B) 10 more items can be uniquely identified.

(C) 2 times as many items can be uniquely identified.

(D) 10 times as many items can be uniquely identified.

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48. Which of the following has the greatest potential for compromising a user's personal privacy?

(A) A group of cookies stored by the user's Web browser

(B) The Internet Protocol (IP) address of the user's computer

(C) The user's e-mail address

(D) The user's public key used for encryption

---

49. The procedure below is intended to display the index in a list of unique names (`nameList`) where a particular name (`targetName`) is found. If `targetName` is not found in `nameList`, the code should display `0`.

```
PROCEDURE FindName (nameList, targetName)
{
   index ← 0
   FOR EACH name IN nameList
   {
      index ← index + 1
      IF (name = targetName)
      {
         foundIndex ← index
      }
      ELSE
      {
         foundIndex ← 0
      }
   }
   DISPLAY (foundIndex)
}
```

Which of the following procedure calls can be used to demonstrate that the procedure does NOT work as intended?

(A) `FindName (["Andrea", "Ben"], "Ben")`

(B) `FindName (["Andrea", "Ben"], "Diane")`

(C) `FindName (["Andrea", "Ben", "Chris"], "Ben")`

(D) `FindName (["Andrea", "Chris", "Diane"], "Ben")`

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50. Both online newspapers and social media sites are used to distribute information on the Internet. Which of the following best describes an advantage that online newspapers have over social media sites?

(A) The ability to distribute information instantaneously

(B) The ability to provide credibility to the information distributed

(C) The ability to provide information that is widely accessible

(D) The ability to provide media-rich content for low cost

---

51. When a cellular telephone user places a call, the carrier transmits the caller's voice as well as the voice of the person who is called. The encoded voices are the data of the call. In addition to transmitting the data, the carrier also stores metadata. The metadata of the call include information such as the time the call is placed and the phone numbers of both participants. For which of the following goals would it be more useful to computationally analyze the metadata instead of the data?

I. To determine if a caller frequently uses a specific word

II. To estimate the number of phone calls that will be placed next Monday between 10:30 A.M. and noon.

III. To generate a list of criminal suspects when given the telephone number of a known criminal

(A) I only

(B) II only

(C) II and III only

(D) I, II, and III

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52. In the procedure `Mystery` below, the parameter `number` is a positive integer.

```
PROCEDURE Mystery (number)
{
   REPEAT UNTIL (number ≤ 0)
   {
      number ← number - 2
   }
   IF (number = 0)
   {
      RETURN (true)
   }
   ELSE
   {
      RETURN (false)
   }
}
```

Which of the following best describes the result of running the procedure `Mystery`?

(A) The procedure returns `true` when the initial value of `number` is 2, and it otherwise returns `false`.

(B) The procedure returns `true` when the initial value of `number` is greater than 2, and it otherwise returns `false`.

(C) The procedure returns `true` when the initial value of `number` is even, and it otherwise returns `false`.

(D) The procedure returns `true` when the initial value of `number` is odd, and it otherwise returns `false`.

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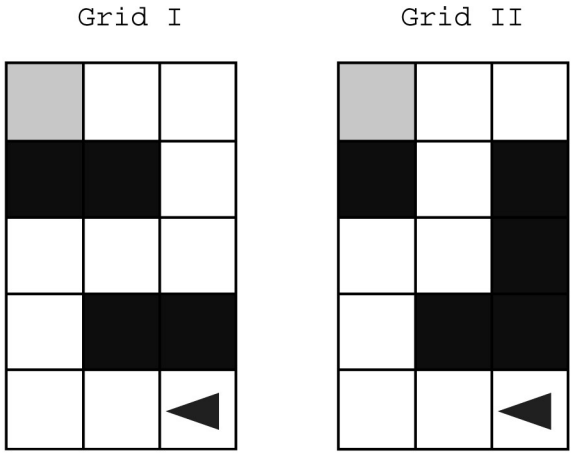
53. Two grids are shown below. Each grid contains a robot represented as a triangle. Both robots are initially facing left. Each robot can move into a white or gray square, but cannot move into a black region.



For each grid, the program below is intended to move the robot to the gray square. The program uses the procedure `Goal_Reached ()`, which evaluates to `true` if the robot is in the gray square and evaluates to `false` otherwise.

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

For which of the grids does the program correctly move the robot to the gray square?

(A) Grid I only

(B) Grid II only

(C) Both grid I and grid II

(D) Neither grid I nor grid II

GO ON TO THE NEXT PAGE.

54. Historically, it has been observed that computer processing speeds tend to double every two years. Which of the following best describes how technology companies can use this observation for planning purposes?

(A) Technology companies can accurately predict the dates when new computing innovations will be available to use.

(B) Technology companies can plan to double the costs of new products each time advances in processing speed occur.

(C) Technology companies can set research and development goals based on anticipated processing speeds.

(D) Technology companies can spend less effort developing new processors because processing speed will always improve at the observed rate.

---

55. A computer program uses 3 bits to represent integers. When the program adds the decimal (base 10) numbers 5 and 3, the result is 0. Which of the following is the best explanation for the result?

(A) An overflow error occurred.

(B) A round-off error occurred.

(C) The result was affected by lossy data compression.

(D) The result was approximated by a floating-point representation.

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56. A programmer wrote the code segment below to display the average of all the elements in a list called `numbers`. There is always at least one number in the list.

```
Line 1:  count ← 0
Line 2:  sum ← 0
Line 3:  FOR EACH value IN numbers
Line 4:  {
Line 5:     count ← count + 1
Line 6:     sum ← sum + value
Line 7:     average ← sum / count
Line 8:  }
Line 9:  DISPLAY (average)
```

The programmer wants to reduce the number of operations that are performed when the program is run. Which change will result in a correct program with a reduced number of operations performed?

(A) Interchanging line 1 and line 2

(B) Interchanging line 5 and line 6

(C) Interchanging line 6 and line 7

(D) Interchanging line 7 and line 8

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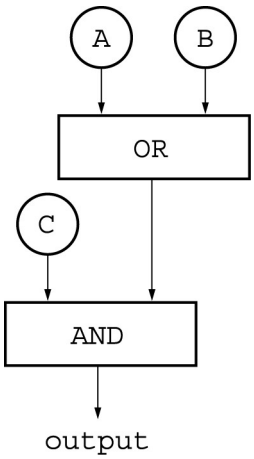
57. The diagram below shows a circuit composed of two logic gates labeled `OR` and `AND`. Each gate takes two inputs and produces a single output.



If the inputs `A` and `C` are both `true`, which of the following best describes the output of the `AND` gate?

(A) The output will be `true` no matter what the value of input `B` is.

(B) The output will be `false` no matter what the value of input `B` is.

(C) The output will be `true` if input `B` is `true`; otherwise it will be `false`.

(D) The output will be `false` if input `B` is `true`; otherwise it will be `true`.

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58. A certain computer game is played between a human player and a computer-controlled player. Every time the computer-controlled player has a turn, the game runs slowly because the computer evaluates all potential moves and selects the best one. Which of the following best describes the possibility of improving the running speed of the game?

(A) The game's running speed can only be improved if the game is played between two human players instead of with the computer-controlled player.

(B) The game's running speed might be improved by using a process that finds approximate solutions every time the computer-controlled player has a turn.

(C) The game's running speed cannot be improved because computers can only be programmed to find the best possible solution.

(D) The game's running speed cannot be improved because the game is an example of an algorithm that does not run in a reasonable time.

---

59. Many Web browsers allow users to open anonymous windows. During a browsing session in an anonymous window, the browser does not record a browsing history or a list of downloaded files. When the anonymous window is exited, cookies created during the session are deleted. Which of the following statements about browsing sessions in an anonymous window is true?

(A) The activities of a user browsing in an anonymous window will not be visible to people who monitor the user's network, such as the system administrator.

(B) Items placed in a Web store's shopping cart for future purchase during the anonymous browsing session will not be saved on the user's computer.

(C) A user will not be able to log in to e-mail or social media accounts during the anonymous browsing session.

(D) A user browsing in an anonymous window will be protected from viruses launched from any Web sites visited or files downloaded.

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60. Which of the following best describes a Distributed Denial of Service (DDoS) attack?

(A) An attempt by a country to deny its citizens access to the Internet

(B) An attempt to deny users access to a Web site's resources by flooding the Web site with requests from multiple systems

(C) An attempt by one user to deny service to another user by posting material on a social network

(D) An attempt by a user of the Internet to get private information from a secure database

---

61. A program is expressed in a programming language. Which of the following is true of the program?

(A) The program can also be expressed as binary code, but will be more easily understood by humans when expressed in a higher-level programming language.

(B) The program can also be expressed as binary code, which will reduce the likelihood of errors.

(C) The program cannot be expressed as binary code, because binary code can only be used to represent data.

(D) Some parts of the program can be expressed as binary code, but operations must be expressed using a higher-level programming language.

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62. A programmer is deciding between using a linear or binary search to find a target value in a sorted list. Which of the following is true?

(A) In all cases, a binary search of a sorted list requires fewer comparisons than a linear search.

(B) Generally, the advantage of using a binary search over a linear search increases as the size of the list increases.

(C) A linear search will generally run faster than a binary search because a linear search requires fewer lines of code to implement.

(D) Using a linear search is preferable to using a binary search if there is a chance that the target may not be found in the list.

---

63. A code segment will be used to swap the values of the variables `a` and `b` using the temporary variable `temp`.

Which of the following code segments correctly swaps the values of `a` and `b` ?

(A)
```
a ← b
temp ← a
b ← temp
```

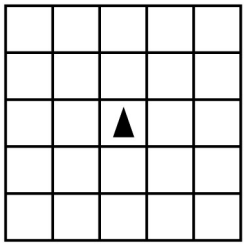
(B)
```
temp ← a
a ← b
b ← temp
```

(C)
```
temp ← a
a ← temp
a ← b
```

(D)
```
temp ← a
b ← temp
a ← b
```

GO ON TO THE NEXT PAGE.

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

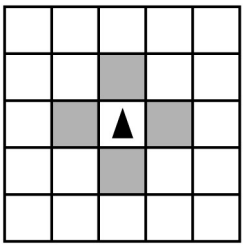


The following code segment is used to move the robot within the grid.

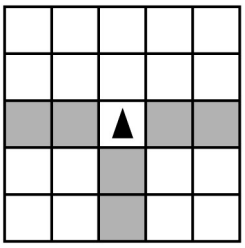
```
x ← RANDOM (1, 3)
REPEAT x TIMES
{
   ROTATE_RIGHT ()
}
y ← RANDOM (1, 2)
REPEAT y TIMES
{
   MOVE_FORWARD ()
}
```

A gray square represents a possible final location of the robot after the code segment is executed. Which of the following represents all possible final locations for the robot?

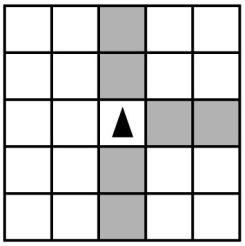
(A)



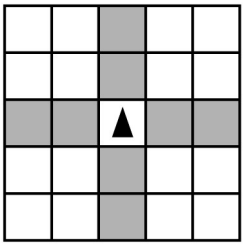
(B)



(C)



(D)



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65. Digital images are often represented by the red, green, and blue values (an RGB triplet) of each individual pixel in the image. A photographer is manipulating a digital image and overwriting the original image. Which of the following describes a lossless transformation of the digital image?

(A) Compressing the image in a way that may lose information but will suffer only a small loss of image quality.

(B) Creating the gray scale of an image by averaging the amounts of red, green, and blue in each pixel and assigning this new value to the corresponding pixel in the new image. The new value of each pixel represents a shade of gray, ranging from white to black.

(C) Creating the negative of an image by creating a new RGB triplet for each pixel in which each value is calculated by subtracting the original value from 255. The negative of an image is reversed from the original; light areas appear dark, and colors are reversed.

(D) Modifying part of the image by taking the pixels in one part of the picture and copying them to the pixels in another part of the picture.

---

66. In the program below, y is a positive integer (e.g., 1, 2, 3, …).

```
result ← 0
REPEAT 3 TIMES
    REPEAT y TIMES
        result ← result + 1
```

What is the value of `result` after running the program?

(A) $y + 3$

(B) $3y$

(C) y^3

(D) 3^y

GO ON TO THE NEXT PAGE.

Directions: For each of the questions or incomplete statements below, two of the suggested answers will be 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 both of the appropriate letters in the corresponding space on the answer sheet.

67. A local government uses Short Message Service (SMS) text messages to alert local residents when roads are closed.

    Which of the following are true statements regarding the benefits of using SMS text messages for the purpose described?

    Select two answers.

    (A) SMS text messages are guaranteed to reach all residents affected by the road closures.

    (B) SMS text messages are likely to reach recipients quickly.

    (C) SMS text messages are useful for providing detailed detour instructions.

    (D) SMS text messages can be sent to multiple recipients.

---

68. Which of the following can be represented by a single binary digit?

    Select two answers.

    (A) The position of the minute hand of a clock

    (B) The remainder when dividing a whole number by 2

    (C) The value of a Boolean variable

    (D) The volume of a car radio

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69. Which of the following Boolean expressions are equivalent to the expression `num ≥ 15` ?

Select two answers.

(A) `(num > 15) AND (num = 15)`

(B) `(num > 15) OR (num = 15)`

(C) `NOT (num < 15)`

(D) `NOT (num < 16)`

---

70. Researchers have developed a simulation of packets traveling between server computers and client computers in a network. Of the following, which two outcomes are most likely to be results of the simulation?

Select two answers.

(A) Better understanding of the effect of temporarily unavailable network connections

(B) Better understanding of the effect of using hexadecimal representations for binary data

(C) Better understanding of the impact of access to public data in identifying solutions to problems

(D) Better understanding of the impact of increased connection speeds for frequently visited servers

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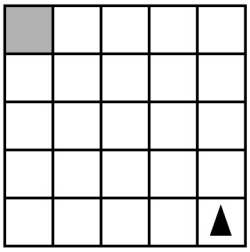
71. The question below uses a robot in a grid of squares. The robot is represented as a triangle, which is initially in the bottom-right square of the grid and facing toward the top of the grid.



Which of the following code segments can be used to move the robot to the gray square?

Select two answers.

(A)
```
REPEAT 4 TIMES
{
   MOVE_FORWARD ()
   ROTATE_LEFT ()
   MOVE_FORWARD ()
   ROTATE_RIGHT ()
}
```

(B)
```
REPEAT 4 TIMES
{
   ROTATE_LEFT ()
   MOVE_FORWARD ()
   MOVE_FORWARD ()
   ROTATE_RIGHT ()
}
```

(C)
```
REPEAT 2 TIMES
{
   REPEAT 4 TIMES
   {
      MOVE_FORWARD ()
   }
   ROTATE_LEFT ()
}
```

(D)
```
REPEAT 2 TIMES
{
   REPEAT 2 TIMES
   {
      MOVE_FORWARD ()
      MOVE_FORWARD ()
      ROTATE_LEFT ()
   }
}
```

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72. Which of the following are benefits of using well-named variables in a computer program?

Select two answers.

(A) The program will run faster.

(B) The program will be easier for people to read.

(C) The program will have a greater data storage capacity.

(D) The program will be easier to modify in the future.

---

73. A school library allows students to borrow laptops. A computer program is used to count the number of times a particular laptop has been borrowed from the library (`borrows`) and the number of times the same laptop has been returned to the library (`returns`). Which of the following indicate that a particular laptop is not currently borrowed?

Select two answers.

(A) The difference between `borrows` and `returns` is zero.

(B) The product of `borrows` and `returns` is a positive even number.

(C) The quotient when `borrows` is divided by `returns` is greater than 1.

(D) The sum of `borrows` and `returns` is a positive even number.

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74. In a certain district, 20 percent of the voters are expected to vote for Candidate A in an election. The computer program below is intended to simulate the result of the election with `n` voters, and display the number of votes received by Candidate A.

```
Line 1:  sum ← 0
Line 2:  REPEAT n TIMES
Line 3:  {
Line 4:     IF (<MISSING CONDITION>)
Line 5:     {
Line 6:        sum ← sum + 1
Line 7:     }
Line 8:  }
Line 9:  DISPLAY (sum)
```

Which of the following can be used to replace `<MISSING CONDITION>` in line 4 so that the program works as intended?

Select two answers.

(A) `RANDOM (1, 5) = 1`

(B) `RANDOM (1, 5) ≤ 2`

(C) `RANDOM (1, 10) = 2`

(D) `RANDOM (1, 10) ≤ 2`

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

Introduction

This section provides a description of how the questions in the AP Practice Exam correspond to the components of the curriculum framework included in the *AP Computer Science Principles Course and Exam Description*. For each question in the AP Practice Exam, the enduring understandings, learning objectives, computational thinking practices, and essential knowledge statements from the curriculum framework are indicated. Note that in cases where multiple learning objectives are provided for a question, the primary learning objective is listed first, along with the associated computational thinking practice and essential knowledge statement(s). In addition, the correct response is provided along with a justification for why it is correct. There are additional explanations that address why the other responses are incorrect.

The AP Computer Science Principles Exam is 2 hours long and includes 74 multiple-choice questions. There are two types of multiple-choice questions:

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

Multiple-Choice Questions

The multiple-choice questions on this exam are designed to elicit evidence of student achievement of the course learning objectives. This includes the application of computational thinking practices and course content as specified in the essential knowledge statements.

Curriculum 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	5.2.1B 5.2.1C

(A)	This option is incorrect. While `r` had an initial value of 1, its value changed in line 4.
(B)	This option is incorrect. While `r` had an initial value of 1, its value changed in line 4. While `s` had an initial value of 2, its value changed in line 5 to the value of `t`, which is 3.
(C)	**This option is correct.** Line 1 assigns 1 to `r`. Line 2 assigns 2 to `s`. Line 3 assigns 3 to `t`. Line 4 assigns the value of `s`, which is 2, to `r`. Line 5 assigns the value of `t`, which is 3, to `s`. Line 6 displays 2. Line 7 displays 3.
(D)	This option is incorrect. The `DISPLAY` commands first show the value of `r`, which is 2, and then the value of `s`, which is 3.

Question 2

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	5.1.2D 5.1.2F

(A)	This option is incorrect. Program documentation is written throughout the development process, and it should be modified as the program is written and modified. Since programs are often modified after they are first written, the documentation should be modified as well.
(B)	This option is incorrect. Program documentation is needed not only as the program is being developed but also after the program is completed.
(C)	This option is incorrect. When a programmer works individually on a project, the process of documentation helps the programmer remember assumptions that were made, what different parts of the program are expected to do, and how the different parts work together. When a programmer works on the program in the future, the documentation facilitates easy and accurate modifications.
(D)	**This option is correct.** During initial program development, documentation can allow the writer to organize his or her thinking, state assumptions about input, and explain the path of future development. When modifications are made to existing programs, documentation is used to record the changes or additions to an existing program.

Question 3

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

(A)	This option is incorrect. A device driver typically accommodates the connection of some peripheral device to a single machine. This process does not necessarily involve connection to the Internet.
(B)	**This option is correct.** Connecting new devices to the Internet is enabled by the assignment of an IP address.
(C)	This option is incorrect. Packets are pieces of data that travel the Internet. They do not represent the devices themselves.
(D)	This option is incorrect. A website does not represent a device.

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 4.1.1D

(A)	**This option is correct.** Because the value of the variable `j` starts at 1 and increases by 2, the value of `j` will always be odd. Thus the value of `j` will never equal 6. If `<MISSING CONDITION>` is replaced with the expression `j = 6`, the expression will always evaluate to `false`, and the loop will never end.
(B)	This option is incorrect. The value of the variable `j` starts at 1 and increases by 2. If `<MISSING CONDITION>` is replaced with the expression `j ≥ 6`, the expression will evaluate to `true` when `j` is 7 and the loop will end.
(C)	This option is incorrect. The value of the variable `j` starts at 1 and increases by 2. If `<MISSING CONDITION>` is replaced with the expression `j = 7`, the expression will evaluate to `true` when `j` is 7 and the loop will end.
(D)	This option is incorrect. The value of the variable `j` starts at 1 and increases by 2. If `<MISSING CONDITION>` is replaced with the expression `j > 7`, the expression will evaluate to `true` when `j` is 9 and the loop will end.

Question 5

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.3 Models and simulations use abstraction to generate new understanding and knowledge. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**2.3.1** Use models and simulations to represent phenomena. **4.1.1** Develop an algorithm for implementation in a program.	**P3** Abstracting **P2** Creating computational artifacts	2.3.1A 2.3.1B 2.3.1C 4.1.1B 4.1.1C 4.1.1.D

(A)	This option is incorrect. In the simulation, a `coin_flip` value of `0` represents heads, and thus a `coin_flip` value of `1` represents tails. When `coin_flip` equals `1`, it signifies that the last coin flip of the simulation was tails. This information by itself would not necessarily signify that an equal number of heads and tails occurred in the simulation.
(B)	This option is incorrect. In the simulation, the variable `flip_counter` represents the number of times a coin was flipped. When `flip_counter` equals `1`, only one coin has been flipped. This information does not lead to knowledge about the result of the simulation.
(C)	This option is incorrect. In the simulation, the variable `flip_counter` represents the number of times a coin was flipped. When `flip_counter` equals `2`, only two coins have been flipped. This information does not lead to knowledge about the result of the simulation.
(D)	**This option is correct.** There are 4 trials in the simulation, and the goal is to determine if there were an equal number of head and tails, or, in other words, 2 heads. In Step 2, `heads_counter` is incremented when `coin_flip` represents heads. The simulation will result in an equal number of heads and tails if `heads_counter = 2`.

Question 6

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 4.1.1C

(A)	This option is incorrect. Iteration is the repetition of part of an algorithm until a condition is met. The existing algorithm already included iteration since it needed to process a list.
(B)	This option is incorrect. Searching is not a basic program structure but rather an algorithm that uses programming structures such as sequence, selection, and iteration.
(C)	**This option is correct.** The original algorithm added all the integers, but the new algorithm needs to add only the even ones. The new algorithm needs to choose whether or not the current integer in the list is even.
(D)	This option is incorrect. Sequencing is the application of each step of an algorithm in the order in which the statements are given. The existing algorithm already included sequencing because it needed to compute a sum of several items.

Question 7

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 answers that address these issues with the Internet and the systems built on it.	**P1** Connecting computing	6.3.1H 6.3.1L

(A)	This option is incorrect. Public key encryption is widely used because of the functionality it provides in addressing cybersecurity issues when sending information across the Internet.
(B)	This option is incorrect. Secure electronic payment systems are designed to address cybersecurity issues and are not considered a risk.
(C)	**This option is correct.** As an email message passes through the Internet, it goes through intermediate computers and routers. These computers and routers could read the contents of the email. The credit card number could be read from the email.
(D)	This option is incorrect. Automated teller machines are designed to address cybersecurity issues.

Question 8

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions. **5.5** Programming uses mathematical and logical concepts.	**5.3.1** Use abstraction to manage complexity in programs. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P3** Abstracting	5.3.1A 5.3.1B 5.3.1C 5.3.1D 5.3.1G 5.3.1K 5.3.1L 5.5.1J

(A)	This option is incorrect. The `resultList` contains only items from `inputList1` that are also found in `inputList2`.
(B)	**This option is correct.** Each item in `inputList1` is checked to see if it appears in `inputList2`. If the item appears in `inputList2`, the item is appended to `resultList`. Since `resultList` is initially empty, at the end of the `FOR EACH` loop `resultList` will contain precisely the elements that appear in both initial lists.
(C)	This option is incorrect. Each item in `inputList1` is checked to see if it appears in `inputList2`. If the item appears in `inputList2`, the item is appended to `resultList`. Items that appear in both lists are the only items that appear in `resultList`.
(D)	This option is incorrect. The `FOR EACH` loop considers every item in `inputList1`. The statement `IF (IsFound (inputList2, item))` evaluates to `true` if `item` also appears in `inputList2`. Thus, the elements of `resultList` must appear in `inputList2`.

Question 9

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
3.2 Computing facilitates exploration and the discovery of connections in information.	**3.2.2** Determine how large data sets impact the use of computational processes to discover information and knowledge.	**P3** Abstraction	3.2.2E 3.2.2H

(A)	This option is incorrect. Techniques to process data sets change as the size of data sets increase. Larger data sets often take a longer time to process.
(B)	**This option is correct.** The number of statements in a program is not likely to affect how a program will handle larger data sets. The efficiency of a program is independent of the number of statements it contains. There are some programs with very few statements that take a long time to execute, as well as programs with many statements that take little time to execute.
(C)	This option is incorrect. The ability to process larger data sets relies in part on the amount of memory a program uses. Larger data sets often require larger amounts of memory as they are being processed.
(D)	This option is incorrect. Techniques to store data sets change as the size of data sets increase. Larger data sets by their nature require more storage space.

Question 10

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 answers that address these issues with the Internet and the systems built on it.	**P1** Connecting computing	6.3.1C 6.3.1F

(A)	**This option is correct.** Phishing attacks are characterized by a communication from a person trying to trick another person into divulging personal information. Because the phone number on a bank card is public information and not personal, this request does not indicate a phishing attack.
(B)	This option is incorrect. Emails that request the user to click on an unknown link, as well as requests to share password information, are indicative of a phishing attack.
(C)	This option is incorrect. Emails that request the user to enter personal information, such as date of birth or Social Security number, are indicative of a phishing attack.
(D)	This option is incorrect. Emails that use the possibility of reward for the user and ask for personal information, such as a bank account number, are indicative of a phishing attack.

Question 11

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	7.3.1A 7.3.1B 7.3.1F 7.3.1Q

(A)	This option is incorrect. Freeware or shareware is generally intended for download onto a home computer and this use is considered ethical.
(B)	This option is incorrect. App stores are online retailers who sell games and other applications that are downloaded directly onto devices. This use is considered ethical.
(C)	**This option is correct.** Single-user copies of software are meant for one individual to use. Computer labs are meant for public use, so installing the software on the computers raises ethical concerns.
(D)	This option is incorrect. Online searches themselves are ethical, even if for copyrighted materials.

Question 12

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	2.2.3A 2.2.3B

(A)	This option is incorrect. While statement I is correct, low-level programs contain short sequences of letters and/or numbers, which make them harder to debug (statement III). These languages generally provide limited capabilities for data and procedural abstraction (statement II).
(B)	This option is incorrect. While statements I and III are correct, low-level languages generally have limited capabilities for data and procedural abstraction (statement II).
(C)	This option is incorrect. Statements II and III are correct. However, low-level programs contain short sequences of letters and/or numbers, which make them harder to read (statement I).
(D)	**This option is correct.** Low-level programs contain short sequences of letters and/or numbers, which make them harder to read (statement I) and harder to debug (statement III). These low-level languages also generally have limited capabilities for data and procedural abstraction action (statement II).

Question 13

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 3.3.1G

(A)	**This option is correct.** The representation of sound as data involves the computational manipulation of information. For one copy of a song to have a lower sound quality than another copy, a lower ratio of bits per second must have been used.
(B)	This option is incorrect. The representation of sound as data involves the computational manipulation of information. For one copy of a song to have a lower sound quality than another copy, a lower ratio of bits per second must have been used. Because the student noticed that the saved copy is of lower sound quality, it was not saved using more bits per second than the original song.
(C)	This option is incorrect. If the song was saved using a lossless compression technique, there should be no change in sound quality.
(D)	This option is incorrect. Digital information that is saved in one location on a computer can be saved to another location exactly, with no change in sound quality.

Question 14

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.4 Programs are developed, maintained, and used by people for different purposes. **5.5** Programming uses mathematical and logical concepts.	**5.4.1** Evaluate the correctness of a program. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P4** Analyzing problems and artifacts **P1** Connecting computing	5.4.1E 5.4.1F 5.4.1I 5.5.1H 5.5.1J

(A)	**This option is correct.** The variable `count` is initially set to 0 and is incremented only when the current item in the list (represented by the variable `n`) equals the value of the variable `target`.
(B)	This option is incorrect. If `target` does not appear in a list, the program will accurately display the value 0. The value of `count` is initialized to 0, and it never changes in the program if `target` does not appear in the list.
(C)	This option is incorrect. If `target` appears in a list more than once, the program will accurately display the number of times it appeared. The value of `count` is increased each time the statement `IF (n = target)` is `true`.
(D)	This option is incorrect. When `target` appears as the last element of the list, the statement `IF (n = target)` will be `true` and the value of `count` will change from 0 to 1.

Question 15

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts. **5.2** People write programs to execute algorithms.	**5.5.1** Employ appropriate mathematical and logical concepts in programming. **5.2.1** Explain how programs implement algorithms.	**P1** Connecting computing **P3** Abstracting	5.5.1F 5.5.1G 5.2.1C

(A)	This option is incorrect. Since variable `x` stores the value 5, the expression `x < 0` evaluates to `false` and the code in the first `ELSE` statement is executed. `"Foxtrot"` can only be displayed if `x < 0` evaluates to `true`.
(B)	This option is incorrect. Since variable `x` stores the value 5, the expression `x < 0` evaluates to `false` and the code in the first `ELSE` statement is executed. Since the variable `y` stores the value 10, the expression `x > y` evaluates to `false`, and `"Hotel"` cannot be displayed.
(C)	**This option is correct.** Since variable `x` stores the value 5, the expression `x < 0` evaluates to `false` and the code in the first `ELSE` statement is executed. Since the variable `y` stores the value 10, the expression `x > y` evaluates to `false`, and the code in the next `ELSE` statement is executed. Since the expression `y > 0` evaluates to `true`, the statement `DISPLAY("November")` is executed.
(D)	This option is incorrect. Since variable `x` stores the value 5, the expression `x < 0` evaluates to `false` and the code in the first `ELSE` statement is executed. Since the variable `y` stores the value 10, the expression `x > y` evaluates to `false`, and the code in the next `ELSE` statement is executed. Since the expression `y > 0` evaluates to `true`, the statement `DISPLAY ("November")` is executed and the `ELSE` statement to `DISPLAY ("Yankee")` is not executed.

Question 16

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)	This option is incorrect. After the first command: `Draw (1, right)`, the drawing does not match the rest of the commands in the program.
(B)	**This option is correct.** The cursor in this case starts at the top left of the figure in B and ends at the left-middle point of the figure.
(C)	This option is incorrect. While the first five commands of this program match the top, bottom, and middle parts of the figure, the right-most part of the figure does not match the last line of the program: `Draw (1, left).`
(D)	This option is incorrect. The drawing matches the first command: `Draw (1, right).` The next part of the drawing does not match the second command: `Draw (2, down).`

Question 17

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. **5.5** Programming uses mathematical and logical concepts.	**4.1.1** Develop an algorithm for implementation in a program. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P2** Creating computational artifacts **P1** Connecting computing	4.1.1C 5.5.1E 5.5.1F 5.5.1G

(A)	This option is incorrect. An `AND` expression evaluates to `true` only if both conditions are `true`. If `gradePointAverage` is 3.5, the second condition evaluates to `false`.
(B)	**This option is correct.** For an `AND` expression to evaluate to `true`, both conditions must be `true`. If `numberOfAbsences` is 5, that value is less than or equal to 5. If `gradePointAverage` is 3.8, that value is greater than 3.5. The `AND` expression evaluates to `true` and the student is eligible to receive the award.
(C)	This option is incorrect. An `AND` expression evaluates to `true` only if both conditions are `true`. Both the first condition and the second condition evaluate to `false`.
(D)	This option is incorrect. An `AND` expression evaluates to `true` only if both conditions are `true`. If `gradePointAverage` is 3.5, the second condition evaluates to `false`.

Question 18

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
3.2 Computing facilitates exploration and the discovery of connections in information. **7.2** Computing enables innovation in nearly every field.	**3.2.1** Extract information from data to discover and explain connections or trends. **7.2.1** Explain how computing has impacted innovations in other fields.	**P1** Connecting computing	3.2.1A 3.2.1B 3.2.1C 7.2.1A

(A)	This option is incorrect. A credit card company's list of purchases is an example of a large data set. Determining potential fraudulent charges is an example of finding a pattern that is useful to the company.
(B)	This option is incorrect. A suggestion of new products is a useful pattern for a grocery store owner to find. Customers' past purchases is a large set of data.
(C)	**This option is correct.** By current standards, a single high school's list of student grades is not considered a large set of data. Furthermore, identifying 10 students with the highest grade point averages is not an example of finding patterns.
(D)	This option is incorrect. Suggestions for other products to purchase based on viewed items is a useful pattern for an online retailer to find. A collection of all the products their customers are viewing is a large data set.

Question 19

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)	This option is incorrect. The expression `(num MOD 1)` is equivalent to 0, since any number divided by 1 is itself, with a remainder of 0. This code fragment will display `"odd"` every time it is executed.
(B)	This option is incorrect. The expression `(num MOD 1)` is equivalent to 0, since any number divided by 1 is itself, with a remainder of 0. This code fragment will never display `"odd"` no matter what the value of `num` is.
(C)	This option is incorrect. The expression `(num MOD 2)` will compute the remainder when `num` is divided by 2. This code fragment will display `"odd"` when `num` is even, which is the opposite of its intended behavior.
(D)	**This option is correct.** The expression `(num MOD 2)` will compute the remainder when `num` is divided by 2. This code fragment works as intended.

Question 20

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. **6.2.1** Explain characteristics of the Internet and the systems built on it.	**P4** Analyzing problems and artifacts **P5** Communicating	6.2.2B 6.2.1D

(A)	This option is incorrect. If only one link were removed, for instance from F to E, a message from computer E could travel through other computers and connect with E through G or A.
(B)	This option is incorrect. If only two links were removed, for instance from F to E and from F to A, a message from computer E could still reach computer F through the route E-D-G-F.
(C)	**This option is correct.** Any line between two computers represents a way for them to communicate with each other, and a communication between two computers can go through other computers. If the links from F to G, from F to A, and from F to E were broken, it would not be possible for computers E and F to communicate.
(D)	This option is incorrect. While removing four links could isolate computer F from computer E, it is not the minimum number required to accomplish this.

Question 21

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. **6.2.1** Explain characteristics of the Internet and the systems built on it.	**P1** Connecting computing **P5** Communicating	6.3.1C 6.2.1A 6.2.1D

(A)	This option is incorrect. Statement I is false because computers A and D can communicate with each other through one computer, E.
(B)	**This option is correct.** Statement I is false because computers A and D can communicate with each other through one computer, E. Statement II is true because there is a direct link between computers B and C.
(C)	This option is incorrect. While Statement II is true, Statement I is false because computers A and D can communicate with each other through one computer, E.
(D)	This option is incorrect. While Statement I is false, Statement II is true because there is a direct link between computers B and C.

Question 22

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 2.1.1C 2.1.1D 2.1.1E 2.1.1G

(A)	This option is incorrect. The table shows that the letter H is represented by the decimal value 72, which in binary (base 2) is 1001000.
(B)	This option is incorrect. The table shows that the letter I is represented by the decimal value 73, which in binary (base 2) is 1001001.
(C)	**This option is correct.** The table shows that the letter J is represented by the decimal value 74, which in binary (base 2) is 1001010.
(D)	This option is incorrect. The table shows that the letter K is represented by the decimal value 75, which in binary (base 2) is 1001011.

Question 23

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. **6.2.1** Explain characteristics of the Internet and the systems built on it.	**P4** Analyzing problems and artifacts **P5** Communicating	6.2.2F 6.2.2G 6.2.2H 6.2.1D

(A)	**This option is correct.** Digital data on the Internet is sent by breaking data into blocks of bits called packets. The packets are reassembled by the user's computer.
(B)	This option is incorrect. The user's browser makes a request for the file, and the file is broken into packets by the server for transmission. The user's browser does not request each packet in order.
(C)	This option is incorrect. The server does not attempt to connect directly to the user's computer. Rather, packets are sent via routers, and the packets may take different paths to get to the user's computer. If one packet's journey to the user is unsuccessful, that packet is resent by the server.
(D)	This option is incorrect. The server does not repeatedly attempt to connect directly to the user's computer until a connection is made.

Question 24

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.	**2.2.2** Use multiple levels of abstraction to write programs.	**P3** Abstracting	2.2.2A

(A)	This option is incorrect. The current score in a game is likely to change often (statement II).
(B)	**This option is correct.** A constant is a good choice for statement I and statement III because the value of pi and the number of days in a standard calendar week never change.
(C)	This option is incorrect. The current score in a game is likely to change often (statement II).
(D)	This option is incorrect. The current score in a game is likely to change often (statement II).

Question 25

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 3.1.1B 3.1.1D 3.1.1E

(A)	This option is incorrect. The database can be filtered to identify the movies that match with each entry under the column titled Movie Title. Those rows can be compared to calculate the largest value of entries under the column titled Number of Times Purchased.
(B)	**This option is correct.** It is not possible to determine the number of movies purchased by an individual subscriber for a particular month. In this database, information about individual subscribers, such as their ID number, is not stored.
(C)	This option is incorrect. The database can be filtered to identify the rows in which entries in the Movie Title column match a certain movie. Those rows can be processed to calculate the number of different cities in which that movie was purchased.
(D)	This option is incorrect. The database can be filtered to identify the rows in which entries in the City column match a certain city. Those rows can be filtered to identify the rows that fall within a certain month. By summing the Number of Times Purchased values for the filtered rows, the total number of movies purchased in a certain city during a certain month can be calculated.

Question 26

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. **4.1.1** Develop an algorithm for implementation in a program.	**P4** Analyzing problems and artifacts **P2** Creating computational artifacts	4.2.4B 4.1.1A

(A)	**This option is correct.** The robot moves in repeated segments of two `MOVE_FORWARD` and one `ROTATE_RIGHT`. After three of these segments, the robot would end up in the position shown by this response.
(B)	This option is incorrect. Since the parameter `p` is a positive integer, the robot can only end up in one of four possible squares in the grid: in the starting position, in the position two squares above facing up, in the position two squares above and two squares to the right facing right, or in the position two squares to the right facing left. The position shown is not one of the possible ending positions.
(C)	This option is incorrect. Though this is a possible location for the robot to end up in, it is not facing the correct direction. The robot should be facing upward.
(D)	This option is incorrect. Though this is a possible location for the robot to end up in, it is not facing the correct direction. The robot should be facing downward.

Question 27

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. **2.3.2** Use models and simulations to formulate, refine, and test hypotheses.	**P3** Abstracting	2.3.1A 2.3.1D 2.3.2A 2.3.2D 2.3.2E

(A)	This option is incorrect. The bank can add parameters, such as the number of tellers, to the simulation.
(B)	This option is incorrect. By writing a computer simulation, the bank can investigate options without involving the customers.
(C)	This option is incorrect. By running a computer simulation with additional or different features, the bank can decide upon other options to meet their goal of minimizing customer wait time.
(D)	**This option is correct.** Although actual customer data is not available in the bank's simulation, it can give information that relates the average customer wait time for each option.

Question 28

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.2 People write programs to execute algorithms. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**5.2.1** Explain how programs implement algorithms. **4.1.1** Develop an algorithm for implementation in a program.	**P3** Abstracting **P2** Creating computational artifacts	5.2.1A 5.2.1B 5.2.1C 5.2.1D 4.1.1A 4.1.1B 4.1.1C 4.1.1H

(A)	**This option is correct.** Line 3 is executed only if the Boolean expression `a = 0` evaluates to `true`. In the current version of the code the statement `b ← a + 10` would result in the value of 10 being stored in the variable `b`, since `a` equals 0. Changing line 3 to `b ← 10` would not affect the result.
(B)	This option is incorrect. If `a` is 0 and `b` is 2, the original code segment would result in final values of `a = 0` and `b = 10`. However, changing line 3 to `a ← b + 10` would result in final values of `a = 12` and `b = 2`.
(C)	This option is incorrect. If `a` is 30 and `b` is 50, the original code segment would result in final values of `a = 30` and `b = 70`. However, changing line 7 to `b ← 20` would result in final values of `a = 30` and `b = 20`.
(D)	This option is incorrect. If `a` is 30 and `b` is 50, the original code segment would result in final values of `a = 30` and `b = 70`. However, changing line 7 to `a ← b + 20` would result in final values of `a = 70` and `b = 50`.

Question 29

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems. **5.4** Programs are developed, maintained, and used by people for different purposes.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. **5.4.1** Evaluate the correctness of a program.	**P4** Analyzing problems and artifacts	4.2.4C 5.4.1E 5.4.1F 5.4.1G

(A)	This option is incorrect. The program does not work as intended. On the test case `[9, 1, 4, 5]`, the program displays `28` but the correct sum is 19.
(B)	This option is incorrect. The program does display the correct sum of 10 for the test case `[0, 1, 4, 5]`.
(C)	**This option is correct.** Because the variable `sum` is initialized to store the value of the first element of `numList`, and because the iteration block is a `FOR EACH` loop, the value of the first element is added to `sum` twice. Since the first element of the list is `0`, adding this number to the sum does not affect the sum. A non-zero first element would give an incorrect result. In general, a single test case is not sufficient to confirm that a program works as intended.
(D)	This option is incorrect. The test case `[0, 1, 4, 5]` does not confirm that the program works for lists in increasing order. For instance, the program gives a result of `11` for the test case `[1, 2, 3, 4]`, but the correct sum is 10.

Question 30

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. **4.1.2** Express an algorithm in a language.	**P2** Creating computational artifacts **P5** Communicating	4.1.1A 4.1.1B 4.1.1C 4.1.2A 4.1.2B

(A)	**This option is correct.** The initial value of `count` is 1, which is less than 5. The variable `count` is incremented to 2, then 3, then 4, then 5. At this point the condition `count < 5` is `false`, and the algorithm displays the value `5`.
(B)	This option is incorrect. The value of `count` starts at 1 and increases by 1. When the value of `count` reaches 5, the loop terminates and the value of `count` is displayed.
(C)	This option is incorrect. The `DISPLAY` block is not in a loop and is executed only once. Only one number should display.
(D)	This option is incorrect. Only one number should display.

Question 31

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.3 Programming is facilitated by appropriate abstractions. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**5.3.1** Use abstraction to manage complexity in programs. **4.1.1** Develop an algorithm for implementation in a program.	**P3** Abstracting **P2** Creating computational artifacts	5.3.1A 5.3.1B 5.3.1C 5.3.1D 5.3.1E 5.3.1K 5.3.1L 4.1.1A 4.1.1B

(A)	**This option is correct.** When `list1` and `list2` are combined, the `newList` may have duplicates and will likely not be sorted. Performing the `Sort` and then the `RemoveDuplicates` procedures will result in a list that is sorted, has no duplicates, and contains the names of all the books found in either `list1` or `list2`.
(B)	This option is incorrect. If each list is sorted separately and then combined, the combined list will not necessarily be sorted.
(C)	This option is incorrect. Each list may contain the same book. When the lists are combined, there may be duplicates. Because the `Combine` procedure is called on `newList` after the `RemoveDuplicates` procedure, there is no assurance that `newList` has no duplicates.
(D)	This option is incorrect. The first two statements assure that `list1` has duplicates removed and is sorted. The second two statements assure that `list2` has duplicates removed and is sorted. However the combined `newList` may not be sorted, and may have duplicates.

Question 32

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	3.3.1A 3.3.1B

(A)	This option is incorrect. For many users who visit the same few Web pages often, average response time may decrease.
(B)	This option is incorrect. By storing Web pages frequently visited by each user, a user's preferences, interests, or transactions could be monitored. This would have a negative impact on the user's privacy.
(C)	This option is incorrect. Storing several Web pages for every user of the ISP will take a significant amount of storage, since ISPs can serve thousands or millions of users.
(D)	**This option is correct.** The actions of the ISP will only affect how frequently visited pages are loaded into Web browsers. Pages not saved by the ISP are still accessed as they were before.

Question 33

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	6.2.1B 6.2.1C 6.2.1D

(A)	This option is incorrect. The ability to avoid naming conflicts is not affected by how packets are routed.
(B)	**This option is correct.** Routers on the Internet are able to move packets through various paths to reach their final destination, even when some connections have failed. This characterizes the fault-tolerant nature of routing.
(C)	This option is incorrect. The ability to resolve errors in DNS lookups is not affected by how packets are routed.
(D)	This option is incorrect. The ability to use multiple protocols is not affected by how packets are routed.

Question 34

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	2.3.1D

(A)	This option is incorrect. While statements I and II are correct, statement III is also correct because the results of computer simulations may be useful in presenting design possibilities to customers.
(B)	This option is incorrect. While statements I and III are correct, statement II is also correct because simulations can be made that model components and their interactions.
(C)	This option is incorrect. While statements II and III are correct, statement I is also correct because software simulations can usually be built before a prototype car.
(D)	**This option is correct.** Statement I is correct because software simulations can usually be built before a prototype car. Statement II is correct because simulations can be made that model components and their interactions. Statement III is correct because the results of computer simulations may be useful in presenting design possibilities to customers.

Question 35

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems. **6.2** Characteristics of the Internet influence the systems built on it.	**6.1.1** Explain the abstractions in the Internet and how the Internet functions. **6.2.2** Explain how the characteristics of the Internet influence the systems built on it.	**P3** Abstracting **P4** Analyzing problems and artifacts	6.1.1C 6.2.2D

(A)	This option is incorrect. The protocols of the Internet, including HTTP, allow any computers that run that protocol to communicate with each other over the Internet.
(B)	This option is incorrect. The protocols of the Internet, including TCP/IP, allow any computers that run that protocol to send data back and forth to each other. Protocols such as TCP/IP are implemented through software, not hardware, and additional hardware is not required.
(C)	This option is incorrect. All data on a computer is stored in binary. Individual computers can interpret different file formats if each computer contains the appropriate software. The structure and functionality of the Internet does not affect the ability of two computers to share files.
(D)	**This option is correct.** Devices on the Internet communicate using standard protocols, which do not depend on the manufacturer.

Question 36

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.4 Programs are developed, maintained, and used by people for different purposes. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**5.4.1** Evaluate the correctness of a program. **4.1.1** Develop an algorithm for implementation in a program.	**P4** Analyzing problems and artifacts **P2** Creating computational artifacts	5.4.1F 5.4.1I 5.4.1K 4.1.1A 4.1.1B 4.1.1D 4.1.1H

(A)	This option is incorrect. In program II, the value of `i` starts at `n` and finishes at 1, so that `result` stores the sum of `n + (n - 1) + ... + 3 + 2 + 1`. This is the same as `1 + 2 + 3 + ... + n`.
(B)	This option is incorrect. In program I, the value of `i` starts at 1 and finishes at `n`, so that `result` stores the sum of `1 + 2 + 3 + ... + n`.
(C)	**This option is correct.** In program I, the value of `i` starts at 1 and finishes at `n`, so that `result` stores the sum of `1 + 2 + 3 + ... + n`. In program II the value of `i` starts at `n` and finishes at 1, so that `result` stores the sum of `n + ( n - 1 ) + ... + 3 + 2 + 1`. Both programs display the correct sum.
(D)	This option is incorrect. In program I, the value of `i` starts at 1 and finishes at `n`, so that `result` stores the sum of `1 + 2 + 3 + ... + n`. In program II, the value of `i` starts at `n` and finishes at 1, so that `result` stores the sum of `n + ( n - 1 ) + ... + 3 + 2 + 1`. Since both programs display the correct sum, selecting this option, which indicates that neither program displays the correct sum, would be incorrect.

Question 37

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
3.1 People use computer programs to process information to gain insight and knowledge. **3.2** Computing facilitates exploration and the discovery of connections in information.	**3.1.1** Find patterns and test hypotheses about digitally processed information to gain insight and knowledge. **3.2.1** Extract information from data to discover and explain connections or trends.	**P4** Analyzing problems and artifacts **P1** Connecting computing	3.1.1D 3.1.1E 3.2.1A 3.2.1B 3.2.1C

(A)	This option is incorrect. In order to answer this question, the data set would need to include information from students with majors other than computer science and would need to store each student's major.
(B)	**This option is correct.** The data set stores information about an individual student's gender and state. This information can be aggregated to extract information about the percentage of female majors in each state.
(C)	This option is incorrect. In order to answer this question, the data set would need to include information from all students in a certain state, as well as contain information about whether or not each student was a computer science major.
(D)	This option is incorrect. In order to answer this question, the data set would need to contain information identifying the name of the college.

Question 38

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
6.1 The Internet is a network of autonomous systems. **7.1** Computing enhances communication, interaction, and cognition.	**6.1.1** Explain the abstractions in the Internet and how the Internet functions. **7.1.1** Explain how computing innovations affect communication, interaction, and cognition.	**P3** Abstracting **P4** Analyze problems and artifacts	6.1.1A 7.1.1D

(A)	This option is incorrect. Cloud computing uses the Internet to store data on servers. Because cloud computing servers have a tremendous capacity, systems that rely on cloud computing do not have scalability issues.
(B)	This option is incorrect. Cloud computing allows individuals to access their data through a wide variety of Internet-connected devices and includes some protection from data becoming unavailable through loss of or damage to a single personal device.
(C)	**This option is correct.** Cloud computing uses the Internet to store data on servers that are backed up in fail-safe ways. If a user's computer were to stop functioning, the user could access his or her cloud data from another computer.
(D)	This option is incorrect. Cloud computing does not lead to increased security over storage on a personal computer. The data stored on a cloud server could be intercepted in transit to the server or accessed by unauthorized users.

Question 39

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. **4.2.1** Explain the difference between algorithms that run in a reasonable time and those that do not run in a reasonable time. **4.2.3** Explain the existence of undecidable problems in computer science.	**P1** Connecting computing	4.2.2D 4.2.1A 4.2.1C 4.2.1D 4.2.3A

(A)	This option is incorrect. Some problems, such as attempting to break a strongly encrypted message, cannot be solved on modern computers in a reasonable amount of time.
(B)	This option is incorrect. Although some problems will take a very long time to solve even with the fastest computers, some problems cannot be solved with an algorithm for all possible inputs.
(C)	This option is incorrect. Some problems cannot be solved with an algorithm for all possible inputs.
(D)	**This option is correct.** Some problems, such as determining if any program will eventually stop, cannot be solved by an algorithm.

Question 40

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 2.1.1E 2.1.1F 2.1.1G

(A)	This option is incorrect. Converted to decimal, binary 1100 equals decimal 12 and hexadecimal D equals decimal 13. The list 12, 11, 13 is not in order from least to greatest.
(B)	**This option is correct.** Converted to decimal, hexadecimal D equals decimal 13 and binary 1100 equals decimal 12. The list 11, 12, 13 is in order from least to greatest.
(C)	This option is incorrect. Converted to decimal, hexadecimal D equals decimal 13 and binary 1100 equals decimal 12. The list 11, 13, 12 is not in order from least to greatest.
(D)	This option is incorrect. Converted to decimal, hexadecimal D equals decimal 13 and binary 1100 equals decimal 12. The list 13, 11, 12 is not in order from least to greatest.

Question 41

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. **4.1.1** Develop an algorithm for implementation in a program.	**P4** Analyzing problems and artifacts **P2** Creating computational artifacts	4.2.4C 4.1.1H

(A)	This option is incorrect. Algorithm I does not work correctly when the maximum value is less than `-1`. Algorithm II works correctly in all cases.
(B)	This option is incorrect. Algorithm I does not work correctly when the maximum value is less than `-1`. Algorithm II works correctly in all cases.
(C)	**This option is correct.** If the list contained `[-7, -2, -5]`, algorithm I would initially set the value of `max` to `-1`. Since no data value in the list is greater than `-1`, the value of `max` would remain `-1`, which is not the correct behavior. Algorithm II would set the initial value of `max` to `-7`, and then change the value of `max` to `-2`. For all cases, algorithm II would return the correct maximum value in the list.
(D)	This option is incorrect. Algorithm II will correctly identify the maximum value in all cases, including when the input contains both positive and negative input values.

Question 42

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.1 Computing enhances communication, interaction, and cognition. **3.2** Computing facilitates exploration and the discovery of connections in information.	**7.1.1** Explain how computing innovations affect communication, interaction, and cognition. **3.2.1** Extract information from data to discover and explain connections or trends.	**P4** Analyzing problems and artifacts **P1** Connecting computing	7.1.1G 3.2.1B

(A)	This option is incorrect. This question can be answered by filtering the data for the date and the sports category.
(B)	This option is incorrect. This question can be answered by filtering the people and society category that provides the number of requests for a certain political candidate.
(C)	**This option is correct.** The cost of a given product is not tracked by the described search engine.
(D)	This option is incorrect. This question can be answered by searching the arts and entertainment category for opera performances and filtering by region.

Question 43

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	3.2.1B

(A)	**This option is correct.** Because the database stores information on item identification numbers and quantities available, the retailer can search for all item identification numbers that have a quantity of 0.
(B)	This option is incorrect. The database does not store information about individual sales, nor does it store information about gender.
(C)	This option is incorrect. The database does not store information about the age of the people wearing the shoes.
(D)	This option is incorrect. The database does not store information about the date of a particular sale.

Question 44

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. **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	4.2.2A 4.2.2B 4.2.2C 4.2.1C 4.2.1D

(A)	This option is incorrect. A heuristic is a technique that can find an approximate solution more quickly when exact methods are too slow. Calculating a grade can be done exactly and quickly by a program.
(B)	This option is incorrect. Encrypting a folder of digital files does not require a heuristic. Encryption is based on mathematical formulas that process files in a reasonable time.
(C)	**This option is correct.** Finding the shortest driving route is an optimization problem that cannot be solved in a reasonable time, and a heuristic is a technique that can find an approximate solution more quickly when exact methods are too slow.
(D)	This option is incorrect. Sorting a list of numbers can be done exactly and quickly by a program in a reasonable time.

Question 45

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.2 Computing enables innovation in nearly every field. **7.3** Computing has global effects — both beneficial and harmful — on people and society.	**7.2.1** Explain how computing has impacted innovations in other fields. **7.3.1** Analyze the beneficial and harmful effects of computing.	**P1** Connecting computing **P4** Analyzing problems and artifacts	7.2.1D 7.3.1C

(A)	This option is incorrect. Statement III is also correct because under Creative Commons the author can stipulate what kind of modification is allowed by users.
(B)	This option is incorrect. Statement II is not correct because Creative Commons was not meant to be used to prevent sharing.
(C)	**This option is correct.** Statement I is correct because the Creative Commons license is designed to increase the amount of content available to the public for free. Statement III is correct because under Creative Commons the author can stipulate what kind of modification is allowed by users.
(D)	This option is incorrect. Statement III indicates that it would be better for the author to use a Creative Commons license because the author wants to allow permission to use and modify the e-book.

Question 46

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 7.4.1D 7.4.1E

(A)	This option is incorrect. Classes at community centers would be accessible to many citizens and would allow more people to effectively use computing technology. This activity is likely to be effective in reducing the digital divide.
(B)	This option is incorrect. Providing free wireless Internet is likely to give more groups access to the Internet and thus reduce the digital divide.
(C)	**This option is correct.** Putting all government forms on the city website is least likely to be effective in reducing the digital divide because all citizens may not have equitable access to the Internet.
(D)	This option is incorrect. Requiring every city school to have computers that meet minimum standards would allow all students equal access to computing, and thus it is likely to reduce the digital divide.

Question 47

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. **2.1.2** Explain how binary sequences are used to represent digital data.	**P3** Abstracting **P5** Communicating	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.2F

(A)	This option is incorrect. Adding an extra binary digit allows for two times as many items to be identified, not two more.
(B)	This option is incorrect. Adding an extra binary digit allows for two times as many items to be identified, not 10 more.
(C)	**This option is correct.** Using 6-bit binary sequences allows for 2^6 or 64 different items to be identified. Using 7-bit binary sequences allows for 2^7 or 128 different items to be identified. Thus there are two times as many items that can be uniquely identified.
(D)	This option is incorrect. Adding an extra binary digit allows for two times as many items to be identified, not 10 times as many.

Question 48

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.3 Computing has global effects — both beneficial and harmful — on people and society. **6.3** Cybersecurity is an important concern for the Internet and the systems built on it.	**7.3.1** Analyze the beneficial and harmful effects of computing. **6.3.1** Identify existing cybersecurity concerns and potential answers that address these issues with the Internet and the systems built on it.	**P4** Analyzing problems and artifacts **P1** Connecting computing	7.3.1G 7.3.1H 7.3.1I 6.3.1L

(A)	**This option is correct.** The aggregation of information in browser cookies can be used by websites that the user visits to track the user and collect information about the user.
(B)	This option is incorrect. The IP address of a user's computer is required for the user to send and receive information on the Internet. The IP address in itself does not contain any extra information about the user.
(C)	This option is incorrect. A user's email address is required to receive email from other people. An email address in itself does not contain any extra information about the user.
(D)	This option is incorrect. In public key encryption, a person or organization who wants to receive encrypted information via the Internet posts their public key for anyone to use. By its nature, this key is meant to be public and thus does not compromise personal privacy.

Question 49

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.4 Programs are developed, maintained, and used by people for different purposes. **4.2** Algorithms can solve many, but not all, computational problems. **5.3** Programming is facilitated by appropriate abstractions.	**5.4.1** Evaluate the correctness of a program. **4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. **5.3.1** Use abstraction to manage complexity in programs.	**P4** Analyzing problems and artifacts **P3** Abstracting	5.4.1E 5.4.1F 5.4.1G 4.2.4C 5.3.1A 5.3.1B 5.3.1D 5.3.1E

(A)	This option is incorrect. The procedure will display `2`, which is the correct index for the `targetName "Ben"`.
(B)	This option is incorrect. Since `"Diane"` is not in `nameList`, the procedure will display `0`, indicating that the procedure worked as intended.
(C)	**This option is correct.** The procedure will not display the correct value of `foundIndex` if the `targetName` is `"Ben"`. In the `FOR EACH` loop, when the value of `name` is `"Andrea"`, the `ELSE` statement sets `foundIndex` to `0`. When the value of `name` is `"Ben"`, the `ELSE` statement sets `foundIndex` to `1`. But as the loop continues, and the value of `name` is `"Chris"`, the `ELSE` statement sets `foundIndex` to `0`. The procedure displays `0`, even though the correct answer is `1`.
(D)	This option is incorrect. Since `"Ben"` is not in `nameList`, the procedure will display `0`, indicating that the procedure worked as intended.

Question 50

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.1 Computing enhances communication, interaction, and cognition.	**7.1.1** Explain how computing innovations affect communication, interaction, and cognition.	**P4** Analyzing problems and artifacts	7.1.1C 7.1.1H 7.1.1M 7.1.1N

(A)	This option is incorrect. Both online newspapers and social media sites allow people to distribute information instantaneously.
(B)	**This option is correct.** Online newspapers are usually run out in the open, in that the people who create the newspaper are clearly noted on the website. In addition, these online newspapers are often connected to physical newspapers, which are considered credible sources of information.
(C)	This option is incorrect. Both online newspapers and social media sites make information widely accessible.
(D)	This option is incorrect. Both online newspapers and social media sites provide media-rich content at a low cost to the user.

Question 51

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
3.2 Computing facilitates exploration and the discovery of connections in information. **3.1** People use computer programs to process information to gain insight and knowledge.	**3.2.1** Extract information from data to discover and explain connections or trends. **3.1.1** Find patterns and test hypotheses about digitally processed information to gain insight and knowledge.	**P1** Connecting computing **P4** Analyzing problems and artifacts	3.2.1B 3.2.1C 3.2.1G 3.2.1H 3.2.1I 3.1.1E

(A)	This option is incorrect. Statement I is not correct because this goal would require analysis of the data in the call, not the metadata.
(B)	This option is incorrect. Statement III is also correct because the metadata stores the phone numbers of the two parties of a call. Given one phone number, the metadata can be processed to provide all phone numbers that were called by or placed to that person.
(C)	**This option is correct.** Statement II is correct because the repository of stored metadata includes time, so information about the time of calls can be analyzed to make predictions about future calls. Statement III is correct because the metadata stores the phone numbers of the two parties of a call. Given one phone number, the metadata can be processed to provide all phone numbers that were called by or placed to that person.
(D)	This option is incorrect. Statement I is not correct because this goal would require analysis of the data in the call, not the metadata.

Question 52

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. **5.2** People write programs to execute algorithms. **5.5** Programming uses mathematical and logical concepts.	**4.1.1** Develop an algorithm for implementation in a program. **5.2.1** Explain how programs implement algorithms. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P2** Creating computational artifacts **P3** Abstracting **P1** Connecting computing	4.1.1B 4.1.1C 4.1.1D 5.2.1A 5.2.1B 5.2.1C 5.5.1A 5.5.1D 5.5.1E

(A)	This option is incorrect. If the initial value of `number` is 4, the `REPEAT UNTIL` loop will reduce the value of `number` to 2, and then to 0, at which point the loop will terminate. The procedure will return `true`, not `false`.
(B)	This option is incorrect. If the initial value of `number` is 3, the `REPEAT UNTIL` loop will reduce the value of `number` to 1, and then to –1, at which point the loop will terminate. The procedure would return `false` for a value of `number` greater than 2, which contradicts this statement.
(C)	**This option is correct.** The `REPEAT UNTIL` statement subtracts 2 from the parameter `number` until the condition `number ≤ 0` is `true`. After this `REPEAT` loop ends, the value of `number` is either 0 (if the original `number` was even) or –1 (if the original number was odd).
(D)	This option is incorrect. If the initial value of `number` is 3, the `REPEAT UNTIL` loop will reduce the value of `number` to 1, and then to –1, at which point the loop will terminate. The procedure would return `false` for a value of `number` greater than 2, which contradicts this statement.

Question 53

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 4.1.1E 4.1.1H

(A)	**This option is correct.** In Grid I, the robot moves forward to the end of the bottom row, turns right twice, moves forward twice, turns right twice, moves forward until the end of the middle row, turns left twice, moves forward twice, turns left twice, and moves forward until `Goal_Reached` is `true`.
(B)	This option is incorrect. In Grid II, the robot lands in the square in the middle of the grid facing right. It cannot turn right, but it can turn left. It moves forward up to the middle square of the top row, at which point it is facing up. At this point, it turns right and moves forward to the square in the upper right corner of the grid. At this point, the robot cannot move right, it cannot move left, and it cannot move forward. It thus stays in the `REPEAT UNTIL` loop forever, since `Goal_Reached` is never `true`.
(C)	This option is incorrect. While the program moves the robot to the gray square in Grid I, it does not move the robot to the gray square in Grid II.
(D)	This option is incorrect. Although the program will not move the robot to the gray square in Grid II, it will correctly move the robot to the gray square in Grid I.

Question 54

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	7.2.1F

(A)	This option is incorrect. New computing innovations rely on creative endeavors, and knowing when a particular innovation will become operational is difficult.
(B)	This option is incorrect. Improvements in processing speed are not necessarily related to the price of technology. Sometimes improvements in processing speed have resulted in a decrease in the price of technology.
(C)	**This option is correct.** If it is assumed that computer processing speeds will double every two years, then companies can design new products with this assumption.
(D)	This option is incorrect. While processing speed has improved in the past, the companies still need to spend the time and effort to create new processors that have faster speeds.

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.	**2.1.2** Explain how binary sequences are used to represent digital data. **2.1.1** Describe the variety of abstractions used to represent data.	**P5** Communicating **P3** Abstracting	2.1.2A 2.1.2B 2.1.2C 2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E

(A)	**This option is correct.** The binary representations (in 3 bits) of 5 and 3 are 101 and 011, respectively. If these numbers are added, the result would be 1000. Since only 3 bits are used to represent integers in this example, the result would be stored as 000. This is an example of overflow error.
(B)	This option is incorrect. A round-off error occurs when the number of bits provided give an approximate answer. This answer provided, 0, is not close to the correct answer of 8.
(C)	This option is incorrect. Compression techniques are not used in the addition of numbers.
(D)	This option is incorrect. Floating point representations may be used in the addition of real numbers, but these numbers are integers.

Question 56

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
4.2 Algorithms can solve many, but not all, computational problems. **5.5** Programming uses mathematical and logical concepts.	**4.2.4** Evaluate algorithms analytically and empirically for efficiency, correctness, and clarity. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P4** Analyzing problems and artifacts **P1** Connecting computing	4.2.4C 4.2.4D 5.5.1A 5.5.1D 5.5.1H 5.5.1I 5.5.1J

(A)	This option is incorrect. Because line 1 and line 2 are not inside the `FOR EACH` loop, interchanging line 1 and line 2 will have no effect on the number of operations performed.
(B)	This option is incorrect. Line 5 and line 6 are both inside the `FOR EACH` loop. Interchanging them will not affect the number of operations performed.
(C)	This option is incorrect. Line 6 and line 7 are both inside the `FOR EACH` loop. Interchanging them will not affect the number of operations performed. In addition, as a result of the interchanging, `average` will be calculated before `sum` is updated, and the final value of `average` calculated during the last iteration of the loop will be incorrect.
(D)	**This option is correct.** In the current program, line 7 is performed for each value in the list `numbers`. If lines 7 and 8 were interchanged, the average would be calculated only once.

Question 57

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. **5.5** Programming uses mathematical and logical concepts.	**2.2.3** Identify multiple levels of abstractions being used when writing programs. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P3** Abstracting **P1** Connecting computing	2.2.3E 2.2.3F 5.5.1E 5.5.1F 5.5.1G

(A)	**This option is correct.** Because the value of input `A` is `true`, the resulting value coming out of the `OR` gate must be `true`. Because the value of input `C` is `true`, the resulting value coming out of the `AND` gate is `true`. The value of input `B` did not affect this result.
(B)	This option is incorrect. If input `B` is `true`, then the resulting value coming out of the `OR` gate will be `true`. Since the value of `C` is `true`, the resulting value coming out of the `AND` gate is `true`. This result contradicts the statement.
(C)	This option is incorrect. If input `B` is `false`, the resulting value coming out of the `OR` gate will be `true` (since the value of `A` is `true`). Since the value of `C` is `true`, the resulting value coming out of the `AND` gate is `true`. This result contradicts the statement.
(D)	This option is incorrect. If input `B` is `true`, then the resulting value coming out of the `OR` gate will be `true`. Since the value of `C` is `true`, the resulting value coming out of the `AND` gate is `true`. This result contradicts the statement.

Question 58

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. **4.2.2** Explain the difference between solvable and unsolvable problems in computer science.	**P1** Connecting computing	4.2.1C 4.2.1D 4.2.2A 4.2.2B 4.2.2C

(A)	This option is incorrect. Changing the game from single player to multiplayer does not solve the original problem. It might improve the running speed, but other methods of improving performance exist, such as using a heuristic.
(B)	**This option is correct.** Selecting the best move is an optimization problem that cannot be solved in a reasonable time based on the information that the game runs slowly. If the algorithm for selecting the best move is running too slowly, the game may run more quickly if a heuristic is used to find approximate solutions.
(C)	This option is incorrect. In cases where a computer algorithm is attempting to optimize a solution, heuristics may be helpful for finding an approximate solution more quickly when exact methods are too slow.
(D)	This option is incorrect. The game's algorithm to find the best move cannot be solved in a reasonable time. In these cases, heuristic approaches may be helpful to find solutions in a reasonable time.

Question 59

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	7.3.1D 7.3.1G 7.3.1H 7.3.1I 7.3.1J

(A)	This option is incorrect. If a user is working from a network, such as at work or at school, the administrator of that network can monitor all activity of a user, including information that is sent to the Internet.
(B)	**This option is correct.** Because the cookies created during the anonymous browsing session were deleted, no information exists in the browser to inform future visits to the same website. Thus, any shopping cart items will not be available for future purchase.
(C)	This option is incorrect. Users of anonymous browsing sessions may log into email, social media, or other accounts that are on the Internet.
(D)	This option is incorrect. Users of anonymous browsing sessions send data to and receive data from the Internet, including viruses.

Question 60

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 answers that address these issues with the Internet and the systems built on it.	**P1** Connecting computing	6.3.1A 6.3.1C 6.3.1E

(A)	This option is incorrect. DDoS attacks involve using a number of computers to compromise another computer.
(B)	**This option is correct.** DDoS attacks compromise a target by flooding it with requests from multiple systems.
(C)	This option is incorrect. DDoS attacks do not involve one user of a website or service attacking another user of that site.
(D)	This option is incorrect. An attempt by a user of the Internet to get private information from a secure database is an example of a cybersecurity attack, not a DDoS attack.

Question 61

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. **4.1** Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	**2.2.3** Identify multiple levels of abstractions being used when writing programs. **4.1.2** Express an algorithm in a language.	**P3** Abstracting **P5** Communicating	2.2.3A 2.2.3B 2.2.3C 4.1.2A 4.1.2B 4.1.2C 4.1.2F 4.1.2H

(A)	**This option is correct.** Nearly all programming languages, including binary code, are equivalent in terms of being able to express a given algorithm. Higher-level programming languages make it easier for people to read and write a program.
(B)	This option is incorrect. Lower-level languages are written in code that is harder to read and can lead to more programming errors.
(C)	This option is incorrect. Programs can be expressed in any executable language, including binary code.
(D)	This option is incorrect. All parts of a program, including operations, may be expressed in binary code.

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 4.2.4D 4.2.4H

(A)	This option is incorrect. If the target value was the first element in a list of many elements, the linear search would require fewer comparisons.
(B)	**This option is correct.** A binary search on a sorted list compares the target value to the middle value in the list. If that value is not the target value, the search continues on either the lower half or the upper half of the list, depending on whether the target value was lower than or greater than the number in the middle of the list. This process is repeated on each sublist until the target is found or there is no sublist to search. Due to this halving process, a binary search is more efficient than a linear search. As the size of the list increases, the improvement in search efficiency increases.
(C)	This option is incorrect. Programs with fewer lines of code do not necessarily run faster than programs with more lines of code. Also, a linear search does generally not run faster than a binary search.
(D)	This option is incorrect. A linear search would need to check every element to ensure that an element was not found. Because each iteration of a binary search reduces the number of elements that could be equal to the target value by half, every element need not be checked.

Question 63

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	5.2.1A 5.2.1B 5.2.1C

(A)	This option is incorrect. The value of variable `b` is stored in the variable `a`. Then the value of the variable `a` (which now contains the original value of the variable `b`) is stored in the variable `temp`. Finally, the value of the variable `temp` (which now contains the original value of the variable `b`) is stored in the variable `b`. Both `a` and `b` store the original value of `b`.
(B)	**This option is correct.** The value of variable `a` is stored in the variable `temp`. Then the value of the variable `b` is stored in the variable `a`. Finally, the value of the variable `temp` (which now contains the original value of the variable `a`) is stored in the variable `b`.
(C)	This option is incorrect. The value of variable `a` is stored in the variable `temp`. Then the value of the variable `temp` (which now contains the original value of the variable `a`) is stored in the variable `a`. Finally, the value of the variable `b` is stored in the variable `a`. Both `a` and `b` store the original value of `b`.
(D)	This option is incorrect. The value of variable `a` is stored in the variable `temp`. Then the value of the variable `temp` (which now contains the original value of the variable `a`) is stored in the variable `b`. Finally, the value of the variable `b` (which now contains the original value of the variable `a`) is stored in the variable `a`. Both `a` and `b` store the original value of `a`.

Question 64

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. **5.3** Programming is facilitated by appropriate abstractions.	**4.1.1** Develop an algorithm for implementation in a program. **4.1.2** Express an algorithm in a language. **5.3.1** Use abstraction to manage complexity in programs.	**P2** Creating computational artifacts **P5** Communicating	4.1.1A 4.1.1D 4.1.2A 4.1.2B 5.3.1D 5.3.1G

(A)	This option is incorrect. The robot turns right one, two, or three times and cannot end up in a square above its initial position. Also, the robot can move forward one or two times.
(B)	**This option is correct.** The robot turns to the right one, two, or three times and then moves one or two squares forward. The possible final locations are to the right, below, or to the left of the starting position.
(C)	This option is incorrect. The robot turns right one, two, or three times and could end up in a square to the left of its initial position. It cannot end up in a square above its initial position.
(D)	This option is incorrect. The robot turns right one, two, or three times and cannot end up in a square above its initial position.

Question 65

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
3.3 There are trade-offs when representing information as digital data. **2.1** A variety of abstractions built upon binary sequences can be used to represent all digital data.	**3.3.1** Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. **2.1.1** Describe the variety of abstractions used to represent data.	**P4** Analyzing problems and artifacts **P3** Abstracting	3.3.1C 3.3.1D 3.3.1E 2.1.1C

(A)	This option is incorrect. Even a small loss of information is considered lossy. This is not a lossless transformation.
(B)	This option is incorrect. By converting the red, green, and blue values in each pixel into a single number, information has been lost that cannot be restored.
(C)	**This option is correct.** If a negative of the original image is made, each RGB triplet value will be computed by subtracting the original value from 255. The original value can then be restored by subtracting the new value from 255. This process is lossless because the exact original can be restored.
(D)	This option is incorrect. By copying pixels from one part of the image to another part of the image, the old RGB values of the pixels have been lost.

Question 66

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts. **5.2** People write programs to execute algorithms.	**5.5.1** Employ appropriate mathematical and logical concepts in programming. **5.2.1** Explain how programs implement algorithms.	**P1** Connecting computing **P3** Abstracting	5.5.1A 5.5.1D 5.2.1A 5.2.1C

(A)	This option is incorrect. If the value of y was 2, the inner loop would repeat two times and the outer loop would repeat three times. The statement `result ← result + 1` would be executed 3 times 2, or six times. When $y = 2$, the value of $y + 3$ is 5, not 6.
(B)	**This option is correct.** The value of the variable `result` is initially set to 0. The outer `REPEAT` block is executed three times, and the inner `REPEAT` block is executed y times. Any block inside both of these blocks will be executed $3y$ (3 multiplied by y) times. Since the innermost block increases the value of the variable `result` by 1, the final value of the variable `result` is $3y$.
(C)	This option is incorrect. If the value of y was 2, the inner loop would repeat two times and the outer loop would repeat three times. The statement `result ← result + 1` would be executed 3 times 2, or six times. When $y = 2$, the value of y^3 is 8, not 6.
(D)	This option is incorrect. If the value of y was 2, the inner loop would repeat two times and the outer loop would repeat three times. The statement `result ← result + 1` would be executed 3 times 2, or six times. When $y = 2$, the value of 3^y is 9, not 6.

The following questions require the selection of two correct answer choices.

Question 67

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
7.1 Computing enhances communication, interaction, and cognition.	**7.1.1** Explain how computing innovations affect communication, interaction, and cognition.	**P4** Analyzing problems and artifacts	7.1.1A

(A)	This option is incorrect. All residents may not have access to a cell phone or other device that receives SMS text messages. In addition, not all the devices may have power to operate.
(B)	**This option is correct.** SMS text messages use cellular and other networks to reach recipients' cell phones in a very short time. This allows the local government to send emergency messages quickly.
(C)	This option is incorrect. SMS text messages are generally restricted to a relatively small number of characters, and not all residents may have smart phones with the ability to view a Web page with further directions.
(D)	**This option is correct.** A single SMS text message can be broadcast to a list of recipients. The local government can use this feature to initiate a single message that is sent to local residents.

Question 68

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. **2.1.1** Describe the variety of abstractions used to represent data.	**P5** Communicating **P3** Abstracting	2.1.2B 2.1.2D 2.1.2F 2.1.1B 2.1.1C 2.1.1E

(A)	This option is incorrect. The position of a minute hand on a clock can have many possible values. Binary digits can only store two possible values: 0 or 1.
(B)	**This option is correct.** When dividing a whole number (0, 1, 2, 3, …) by 2, the remainder will always be 0 or 1. A binary digit, by its definition, stores 0 or 1.
(C)	**This option is correct.** The value of a Boolean variable is either "true" or "false." These two possible values can be represented by the binary digits 0 or 1.
(D)	This option is incorrect. The volume of a car radio can have many possible values between the lowest possible setting and the highest possible setting. Binary digits can only store two possible values: 0 or 1.

Question 69

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.5 Programming uses mathematical and logical concepts. **5.2** People write programs to execute algorithms.	**5.5.1** Employ appropriate mathematical and logical concepts in programming. **5.2.1** Explain how programs implement algorithms.	**P1** Connecting computing **P3** Abstracting	5.5.1A 5.5.1E 5.5.1F 5.5.1G 5.2.1C

(A)	This option is incorrect. The expression `(num > 15) AND (num = 15)` evaluates to `true` if both conditions are `true`. Because this is mathematically impossible, this expression will always evaluate to `false`. However, the original expression (the expression in this problem) evaluates to `true` when `num` is greater than or equal to 15.
(B)	**This option is correct.** The expression `(num > 15) OR (num = 15)` evaluates to `true` if `(num > 15)` is `true`, or if `(num = 15)` is `true`, or if both are `true`. The original expression (the expression in this problem) evaluates to `true` if `num` is greater than or equal to 15.
(C)	**This option is correct.** The expression `NOT (num < 15)` evaluates to `true` if `(num < 15)` evaluates to `false`. This will happen when the value of `num` is greater than or equal to 15.
(D)	This option is incorrect. The expression `NOT (num < 16)` evaluates to `true` if `(num < 16)` is `false`. This will happen when the value of `num` equals 16 or when the value of `num` is greater than 16. However, the original expression (the expression in this problem) evaluates to `true` when `num` is greater than or equal to 15.

Question 70

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. **2.3.1** Use models and simulations to represent phenomena.	**P3** Abstracting	2.3.2A 2.3.2B 2.3.2F 2.3.1A

(A)	**This option is correct.** A simulation that shows how packets move between clients and servers can show the effects of temporarily unavailable network connections.
(B)	This option is incorrect. The means of representation of the bits in a data packet has no impact on network traffic and would not be a benefit of a network simulation.
(C)	This option is incorrect. The impact of access to public data is determined by the individual users and would not be a benefit of a network simulation.
(D)	**This option is correct.** A simulation that shows how packets move between clients and servers can demonstrate the impact of increased speeds for frequently-visited servers.

Question 71

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)	**This option is correct.** With each iteration of the `REPEAT 4 TIMES` loop, the robot will move one square to the left and one square up and will remain facing up. After four of these iterations, the robot will finish in the gray square.
(B)	This option is incorrect. With each iteration of the `REPEAT 4 TIMES` loop, the robot will move two squares to the left and will remain facing up. On the third iteration of this loop, the robot will attempt to move to a square that is beyond the edge of the grid. At this point, the robot will stay in the lower-left square and the program will terminate.
(C)	**This option is correct.** After one iteration of the `REPEAT 2 TIMES` loop, the robot will end up in the upper-right square facing to the left. After the second iteration of the `REPEAT 2 TIMES` loop, the robot will end up in the upper-left square facing down. The robot has finished in the gray square.
(D)	This option is incorrect. After completing the inner `REPEAT 2 TIMES` loop, the robot will be in the center square of the grid facing down. Since this loop is nested inside another `REPEAT 2 TIMES` loop, these commands are executed again. At the end of execution, the robot will be in the same position at which it started.

Question 72

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
5.4 Programs are developed, maintained, and used by people for different purposes. **2.2** Multiple levels of abstraction are used to write programs or create other computational artifacts.	**5.4.1** Evaluate the correctness of a program. **2.2.2** Use multiple levels of abstraction to write programs.	**P4** Analyzing problems and artifacts **P3** Abstracting	5.4.1C 2.2.2A

(A)	This option is incorrect. The way in which variables are named does not affect the speed at which the program runs.
(B)	**This option is correct.** Using well-named variables allows a person reading the program to better understand the intentions of the programmer.
(C)	This option is incorrect. The way in which variables are named does not affect the amount of storage available.
(D)	**This option is correct.** Using well-named variables allows the original programmer or another programmer to better understand what quantity a variable represents. This in turn can assist the same programmer or another programmer to know what parts of a program to modify and what side effects might occur when a given part of the program is changed in the future.

Question 73

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 3.1.1B

(A)	**This option is correct.** If the difference between the variable `borrows` and the variable `returns` is 0, they must have the same value. This would indicate that each time the particular laptop was borrowed it was returned, which would indicate the laptop is not currently borrowed.
(B)	This option is incorrect. If `borrows` equals 7 and `returns` equals 7, the laptop would be considered not currently borrowed. However, the product of `borrows` and `returns` would be 49, which is not a positive even number.
(C)	This option is incorrect. If `borrows` equals 7 and `returns` equals 7, the laptop would be considered not currently borrowed. However, the quotient of `borrows` and `returns` would be 1, which is not greater than 1.
(D)	**This option is correct.** If a laptop was not currently being borrowed, then the value of the variable `borrows` would equal the value of the variable `returns`. Since these numbers have the same value, the sum of these two numbers would be a positive even number. In this situation, the only way that the sum of `borrows` and `returns` can be a positive even number is if `borrows` and `returns` have the same value.

Question 74

Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
2.3 Models and simulations use abstraction to generate new understanding and knowledge. **5.2** People write programs to execute algorithms. **5.5** Programming uses mathematical and logical concepts.	**2.3.1** Use models and simulations to represent phenomena. **5.2.1** Explain how programs implement algorithms. **5.5.1** Employ appropriate mathematical and logical concepts in programming.	**P2** Creating computational artifacts **P3** Abstracting **P1** Connecting computing	2.3.1A 2.3.1B 5.2.1C 5.5.1A

(A)	**This option is correct.** The statement `RANDOM (1,5)` could evaluate to 1, 2, 3, 4, or 5. There is a one out of five, or 20 percent, chance that it could evaluate to 1. If this happens, the value of `sum` is increased by 1, which simulates a person voting for the candidate.
(B)	This option is incorrect. The statement `RANDOM (1,5)` could evaluate to 1, 2, 3, 4, or 5. There is a two out of five, or 40 percent, chance that it could evaluate to 1 or 2. If this happens, the value of `sum` is increased by 1, which simulates a person voting for the candidate. This does not match the goal of the program, which is to simulate an election in which a certain candidate is expected to receive 20 percent of the vote.
(C)	This option is incorrect. The statement `RANDOM (1, 10)` could evaluate to 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10. There is a one out of 10, or 10 percent, chance that it could evaluate to 2. If this happens, the value of `sum` is increased by 1, which simulates a person voting for the candidate. This does not match the goal of the program, which is to simulate an election in which a certain candidate is expected to receive 20 percent of the vote.
(D)	**This option is correct.** The statement `RANDOM (1, 10)` could evaluate to 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10. There is a two out of 10, or 20 percent, chance that it could evaluate to 1 or 2. If this happens, the value of `sum` is increased by 1, which simulates a person voting for the candidate.