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26. Which of the following statement about algorithmic efficiency is correct?
- (A) Any algorithm that correctly solves a problem will have the same efficiency as any other algorithm that correctly solves that same problem.
 - (B) If an algorithm is considered efficient, it will always be rather simple and contain little code.
 - (C) When determining the overall efficiency of an algorithm, time is the only factor considered.
 - (D) Formal reasoning can be used to determine the efficiency of an algorithm.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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	2
(A) This option is incorrect. Just because the two algorithms solve the same problem, they could do it in very different ways which would imply different efficiencies.				
(B) This option is incorrect. Efficiency does not necessarily follow code complexity. Sometimes the most efficient algorithm may have significant code complexity.				
(C) This option is incorrect. Both time and memory are considered when determining the overall efficiency of an algorithm.				
(D) This option is correct. Very often we use formal reasoning about the algorithm to determine the efficiency of an algorithm.				

27. Which of the following is NOT true regarding metadata?
- (A) In photos, metadata is hidden within the image and is stripped out using pixel processing methods.
 - (B) Metadata can be useful in producing new insights and knowledge when processed with the data itself.
 - (C) Metadata is information about data.
 - (D) Most objects contain metadata including images, audio, and video files.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.2 Computing facilitates exploration and the discovery of connections in information.	2.2.3 Extract information from data to discover and explain connections or trends.	P1 Connecting Computing	3.2.1G	2
(A) This option is correct. This describes a process called stenography. Metadata is associated with the data file not dispersed within it so this statement about metadata is not true.				
(B) This option is incorrect. Sometimes both the metadata and the data can be combined in new and novel ways. For instance, the latitude and longitude metadata can be combined with the picture data to make a map that displays the photos relative to where they were taken.				
(C) This option is incorrect. This is an acceptable definition of data given as an EK in the CED				
(D) This option is incorrect. All of these files can contain extensive metadata.				

28. What are some of the advantages of using models and simulations to mimic a real-world process or system under study?

- I. Models and simulations mimic real-world events without the cost or danger of real world prototypes or testing.
- II. The results of models and simulations may generate new knowledge and new hypotheses related to the phenomena being modeled.
- III. We cannot change the model or simulation as rapidly as we can change the real-world process or system under study, therefore, it allows us to minimize iterations in a model or simulation.

(A) I only

(B) II only

(C) I and II only

(D) I, II and III

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.3 Models and simulations use abstraction to generate new understanding and knowledge.	2.3.1 Use models and simulations to represent phenomena.	P4 Analyzing Problems and Artifacts	2.3.1D	2
(A) This option is incorrect. While this option is one of the reasons we generate models and simulations, it is not the only valid reason among the choices given.				
(B) This option is incorrect. While this option is one of the reasons we generate models and simulations, it is not the only valid reason among the choices given.				
(C) This option is correct. Both choices I and II are valid reasons for generating a model or simulation but choice III is not valid.				
(D) This option is incorrect. Though options I and II are valid reasons, option III is not valid. Generally, it is harder to change a real world system than it is to change a model or simulation. This means that more iterations could be executed using a simulation or model, not less.				

29. Consider the following numbers.

Binary 1101
 Decimal 14
 Hexadecimal F

Which of the following lists them from least to greatest?

- (A) Decimal 14, Binary 1101, Hexadecimal F
- (B) Hexadecimal F, Decimal 14, Binary 1101
- (C) Binary 1101, Decimal 14, Hexadecimal F
- (D) Decimal 14, Hexadecimal F, Binary 1101

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.1 A variety of abstractions built upon binary sequences can be used to represent digital data	2.1.1 Describe the variety of abstractions used to represent data.	P3 Abstracting	2.1.1D	2
(A) This option is incorrect because when converted to decimal; hexadecimal F equals 15, and binary 1101 equals 13. Therefore, the order 14, 13, 15 is not in order from least to greatest.				
(B) This option is incorrect because when converted to decimal; hexadecimal F equals 15, and binary 1101 equals 13. Therefore, the order 15, 14, 13 is not in order from least to greatest.				
(C) This option is correct because when converted to decimal; hexadecimal F equals 15, and binary 1101 equals 13. Therefore, the order 13, 14, 15 is in the correct order.				
(D) This option is incorrect because when converted to decimal; hexadecimal F equals 15, and binary 1101 equals 13. Therefore, the order 14, 15, 13 is not in order from least to greatest.				

30. Which of the following is a characteristic of the fault-tolerant nature of communication on the Internet?

- A. The ability of users to trust that the software they download is free of viruses if it says it is free of malware.
- B. The ability to provide data transmission even when some connections have failed.
- C. The ability to resolve errors in domain name server lookups.
- D. The ability to transfer data using multiple protocols such as hypertext transfer protocol (HTTP), Internet Protocol (IP), and simple mail protocol (SMTP).

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
6.2 Characteristics of the Internet influence the systems built on it	6.2.1 Explain characteristics of the Internet and systems built on it	P5 Communicating	6.2.1D	2
(A) This option is incorrect. Software download on the Internet has nothing to do with the fault tolerant nature of the internet.				
(B) This option is correct Routing on the Internet is both fault tolerant, and redundant. Multiple paths are available for packets to travel from one node to another.				
(C) This option is incorrect. Domain name server lookup errors can be caused by a slow or unresponsive DNS server. While this can be fixed by changing the DNS server, it is not automatically done.				
(D) This option is incorrect. HTTP, IP, SMTP relate to multiple levels of Abstraction that contribute to the functioning of the Internet.				

31. If the post office delivered mail just as routers deliver messages on the Internet, which of the following statements would be true? Select two answers.

- A. One mailman would be responsible for delivering a letter from sender to receiver.
- B. Your mail could not be delivered if a road your mailman was planning to take were under construction.
- C. Letters would be written on the outside of envelopes for all to read instead of letters put inside envelopes.
- D. The mailman would sometimes take a different path to deliver each letter to your home.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
6.2 Characteristics of the Internet and the systems built on it.	6.2.1 Explain characteristics of the Internet and the systems built on it.	P5 Communicating	6.2.1D	2
<hr/>				
(A) This option is incorrect. Messages go through many different routers on the way to their destination.				
<hr/>				
(B) This option is incorrect. Redundancy in the Internet structure allows for a message to get to its destination through many different paths so if one path is broken there are other paths it can take.				
<hr/>				
(C) This option is correct. Unsecured information in the packet is visible to the router.				
<hr/>				
(D) This option is correct. Redundancy allows for many different paths.				
<hr/>				

32. You have been asked to create a computational artifact utilizing a set of tools which are unfamiliar to you. When creating the schedule for delivery, which would **not** be advised if you hope to deliver this product on time:

- (A) Building in time for multiple attempts at generating small pieces of the ultimate deliverable as well as integration time for all the small pieces.
- (B) Allotting a portion of the schedule to find the appropriate tool for the task.
- (C) Searching for existing public domain artifacts that can be combined to advance your project toward the deliverable.
- (D) Planning a set of sequential tasks with precise timing by which you can deliver exactly on the due date.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
1.1 Creative development can be an essential process for creating computational artifacts.	1.1.1 Apply a creative development process when creating computational artifacts.	P2 Creating Computational Artifacts	1.1.1B	1
(A) This option is incorrect because it could possibly take multiple attempts and this would allow time for those attempts and reattempts.				
(B) This option is incorrect because it would be a benefit to set aside some time to find the appropriate tool as every topic could require a different tool.				
(C) This option is incorrect because using public domain artifacts to create another artifact could potentially save time needed to learn a new set of tools.				
(D) This option is correct because planning a sequential set of tasks with precise timing would not leave time for the learning curve of learning a new tool or take into account the iterative process of a project.				

33. Which of the following is true of algorithms?

Select two answers.

- (A) Algorithms are composed of commands which implement sequencing, iteration, and selection by which a task can be completed on a computer.
- (B) When implementing a solution to a problem there is only one algorithm which will typically complete the task.
- (C) Algorithms are very specific to the language in which they are implemented.
- (D) Clarity and readability are important considerations when expressing an algorithm in a language.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.	4.1.2 Express an algorithm in a language.	P5 Communicating	4.1.1A	2
(A) This option is correct. Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages. Sequencing, selection, and iteration are the building blocks of algorithms.				
(B) This option is incorrect. Different algorithms can be developed to solve the same problem. For example, there are many different sorting algorithms such as bubble, selection, insertion, and merge. Any of these algorithms can be used for sorting.				
(C) This option is incorrect. The same algorithm can be expressed in different languages. For example, a specific sorting algorithm can be expressed in natural language, pseudocode, and visual and textual programming languages. Different languages are better suited for expressing different algorithms.				
(D) This option is correct. Algorithms are precise sequences of instructions to accomplish a task.				

34. Since it is well known that you took AP CS Principles, your family decides to discuss the internet with you at a holiday party.

- I. Aunt Minnie says, “The Internet is wholly interesting because it is all about the documents and information in the documents enabling us to become smarter as a society”.
- II. Uncle Jack says, “I love that the Internet connects all the devices such that data can be shared at the speed of light.”
- III. Cousin Josiah comments, “Open standards have been instrumental in the growth of the Internet as multiple networks can be connected without concern so long as they implement established standards.”

Which of the above statements are correct?

- (A) II only
- (B) III only
- (C) I and II only
- (D) II and III only

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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.	P5 Communicating	6.2.2E	3
(A) This option is incorrect. While signals using fiber optic cable and radio wave travel at near the speed of light, other parts of the internet are much slower. Electric pulses on copper wire are many times slower than the speed of light.				
(B) This option is correct as I and II are wrong for reasons mentioned above and below. Only III is correct as standards have helped manufactures confidently invest in producing products which can expect general interoperability.				
(C) This option is incorrect. Choice I is incorrect because it is a description of the World Wide Web not the internet. II is wrong for the same reason mentioned in A above.				
(D) This option is incorrect. Choice II is incorrect. While signals using fiber optic cable and radio wave travel at near the speed of light, other parts of the internet are much slower. Electric pulses on copper wire are many times slower than the speed of light.				

35. Which one of the following is NOT a benefit of the HTTPS protocol?

- (A) HTTPS ensures that only the client and the server can view the packets sent during their communication and they cannot be intercepted by a third party.
- (B) HTTPS verifies the identity of the server through a Certificate Exchange.
- (C) HTTPS encrypts the data before it is broken into packets to ensure its privacy.
- (D) HTTPS provides reasonable assurance by which the user can assume minimal cybersecurity risk of transactions carried out on that site.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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 to address these issues with the Internet and the systems built on it.	P1 Connecting Computing	6.2.2H	5
(A)	This option is correct. The statement is false. It is possible for packets sent via HTTPS to be intercepted and viewed. The data in the packets is encrypted, so the intercepted packets will not be useable by a nefarious agent.			
(B)	The statement is true. Certificate Authorities (CAs) issue digital certificates that validate the ownership of encrypted keys used in secured communication and are based on a trust model.			
(C)	This statement is true. HTTPS uses public key encryption, which is not symmetric. This is an encryption method that is widely used because of the enhanced security associated with its use.			
(D)	This is a true statement because HTTPS uses a certificate authority to obtain the public keys used by the asymmetrical encryption. Exclusion Statement (6.3.1M): The technical details of the process certificate authorities follow are beyond the scope of this course and the AP Exam.			

36. The various protocols used on the internet operate in layers in which the protocol at each layer rely on the protocols at the lower layers to do their jobs, and higher layers (higher level of abstraction) are built on top of the lower layers (lower level of abstraction).

From the list provided choose the two (2) answers that correctly describe the relative levels of abstraction of the internet protocols. For example: if protocol A relies on protocol B, it means that A is a higher level of abstraction than B.

Select two answers.

- (A) TCP/IP is a higher level of abstraction than HTTP
- (B) HTTP is a higher level of abstraction than TCP/IP
- (C) DNS is a higher level of abstraction than TCP/IP
- (D) TCP/IP is a higher level of abstraction than DNS

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
EU 6.1 The Internet is a network of autonomous systems.	IO 6.1.1 Explain the abstractions in the Internet and how the Internet functions.	P3 Abstracting	6.1.1 A	3
<hr/>				
(A) This option is incorrect. HTTP exchanges are conducted over TCP/IP, but HTTP is at a higher level of abstraction. It does not concern itself with the details of TCP/IP, but merely uses its functionality.				
<hr/>				
(B) This option is correct HTTP is a high level protocol, that defines how users of the Internet (clients) request and receive data like web pages, images, video, audio, and files from the servers containing them.				
<hr/>				
(C) This option is correct. DNS translates an URL into an IP address. A DNS request is conducted over TCP/IP - it uses the functionality of TCP/IP.				
<hr/>				
(D) This option is incorrect A DNS request is conducted over TCP/IP. DNS relies on the functionality of TCP/IP and is at a higher level of abstraction.				
<hr/>				

37. How many times will the following loop be executed?

```
x ← 0
```

```
REPEAT UNTIL (x > 5)
```

```
  IF (x MOD 2 = 0)
```

```
    x ← x - 1
```

```
  IF (NOT (x MOD 2) = 0)
```

```
    x ← x + 3
```

(A) The loop will not execute

(B) 3

(C) 6

(D) There is an infinite loop

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
5.5 Programming uses mathematical and logical concepts	5.5.1 Employ appropriate mathematical and logical concepts in programming.	P5 Programming	5.5.1A	5
(A) This option is incorrect. The initial value of x is 0. The loop will not be executed when x greater than 5. Since x is less than 5, the code inside the loop is executed.				
(B) This option is correct. After the third iteration, the value of x is 6. Since 6 is greater than 5, the loop does not run again				
(C) This option is incorrect. After third iteration of the loop the value of x becomes 6 and the loop condition is not met. So the loop stops after 3 iterations.				
(D) This option is incorrect. The loop stops after the third iteration and so it is not an infinite loop.				

38. Which two of the following statements are true about routing on the Internet?

Select two answers.

- (A) Your router receives all the traffic of the Internet and delivers to your computer only the messages intended for you.
- (B) A packet travelling between two computers on the Internet may be rerouted many times along the way.
- (C) A packet contains addressing information to allow routers to decide how best to forward along that packet towards its destination.
- (D) Information travelling between two computers over the Internet will always take the same path.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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.	P3 Abstracting	6.2.2B	2
(A) This option is incorrect. Packets are sent to your router based on your IP address. Your router may receive some packets not intended for you (depending on how your local network is set up), but it does not receive all of the traffic on the internet.				
(B) This option is correct. Packets are routed towards the destination based on its source and destination address. At each node, the router decides, based on calculations involving network statistics and costs, to which neighboring node it is more efficient to send the packet.				
(C) This option is correct. TCP/IP standards dictate that packets include information about their source, their destination, information about reassembling the packets as well as the actual data to be transmitted.				
(D) This option is incorrect. The redundancy of routing (i.e., more than one way to route data) between two points on the Internet increases the reliability of the Internet				

39. Consider the following program code.

```

mystery ← 1
i ← LENGTH list - 1
n ← 1
REPEAT i times
  IF list[n+1] > list[mystery]
    mystery ← n + 1
  n ← n + 1
DISPLAY mystery

```

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

- (A) The index of the largest number in list is displayed
- (B) Display the index of the smallest number in list is displayed
- (C) The largest number in list is displayed
- (D) The smallest number in list is displayed

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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
(A) This option is correct. <code>mystery</code> is set to the index of the greater of the numbers being compared for every number in <code>list</code> and then displayed				
(B) This option is incorrect. <code>mystery</code> is set to the index of the greater of the numbers being compared				
(C) This option is incorrect. <code>mystery</code> is set to the index, not value, of the greatest integer				
(D) This option is incorrect. <code>mystery</code> is not set to the value of the lesser of the two numbers being compared				

40. In the process of engineering a piece of software, which of the following statements would generally be considered to be most accurate?

- (A) Software engineering places much greater emphasis on using the correct set of software commands than it does the sequence of the commands.
- (B) Having multiple people collaborating on the engineering of a piece of software is not very productive as the creation of software is best left to a single person and vision.
- (C) The end user of the software must be considered in the design, implementation, and release of the software.
- (D) Software engineers should not concern themselves with choosing any particular development tool or programming language because they are all essentially the same in functionality and efficiency.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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	5.1.2G	2
(A) This option is incorrect. The correct sequencing of program commands is critical to the ultimate correctness of the program relative to its intended purpose.				
(B) This option is incorrect. Collaboration within and throughout the software development process is very productive at ensuring both the correctness and the efficiency of a given piece of software.				
(C) This option is correct.				
(D) This option is incorrect. Effective use of the tools and/or programming languages in the engineering of a piece of software is critical to both the correctness and the efficiency of a given piece of software relative to its intended use.				

41. You write an algorithm in your program to that calculates and prints the total miles traveled during a road trip. When you test your algorithm, it does not print the correct value. Which of the following would NOT be a productive way to debug the code?

- (A) Go through each line of your algorithm and make sure each one is logical and makes sense.
- (B) Print the value of miles after each calculation
- (C) Ask a colleague to look at your algorithm to see if they can debug the code.
- (D) Delete the entire algorithm and start over

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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	5.1.2J	1
(A) This option is incorrect. Going through each line of an algorithm to find a potential error is a good method for debugging				
(B) This option is incorrect. Checking the value of a variable each time it is changed is a good method for debugging				
(C) This option is incorrect. Collaborating on an algorithm and having someone else look at your code is a good method for debugging				
(D) This option is correct. Rewriting an entire algorithm instead of trying to work with the one you have written is not a good method for debugging.				

42. Your school uses network filtering hardware and software to deny access to blacklisted websites and files. In the school's library there is a student accessing one of the blacklisted websites. Which of the following methods is the student most likely using to defeat the network filtering.

Select two answers.

- (A) The student is using a personal device that is connected to the school's WiFi but since it is not running the network filtering software, the school is unable to filter the Internet traffic.
- (B) The student is using a personal mobile device that is connected to the Internet through a data plan.
- (C) The student is using a school device that allowed the configuration of a proxy server to encrypt the data of the blacklisted website.
- (D) The student used brute force attack methods on the filtering system and discovered the password that allows it to be disabled.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
7.1 Computing has global impact.	7.3.1 Analyze the beneficial and harmful effects of computing.	P1 Connecting Computing	7.3.1I	2
(A) This option is incorrect because the filtering software does not run on the devices connected to the network.				
(B) This option is correct because the school has no control over the Internet Providers of personal devices and can not filter the traffic on them.				
(C) This option is correct because anonymity can be enabled through the use of proxy servers that schools find difficult to block or defeat.				
(D) This option is incorrect because breaking a password using brute force is likely to be time consuming and disabling filtering systems are likely to be disruptive to the entire network.				

43. You have been hired by a company to generate a simulation of a process within their multinational company. You try to convince them that there is significant value to starting with a simple model even though it might not model their process exactly. Which arguments below are viable supports for your position?

Select two answers.

- (A) Models and simulations often omit unnecessary features of the objects or phenomena under investigation.
- (B) Writing very detailed models and simulations will help minimize costs as they are easier to write than more abstract models and simulations.
- (C) Simple models and simulations will execute faster allowing more opportunity for rapid testing and development.
- (D) Less abstract models and simulations omit details to simplify the study of the objects or processes involved.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.3 Models and simulations use abstraction to generate new understanding and knowledge.	2.3.1 Use models and simulations to represent phenomena.	P3 Abstracting	2.3.1A	2
(A) This option is correct. Models and simulations often cannot include all the details of the real-world phenomena as to do so would take too much time or effort with little return.				
(B) This option is incorrect. The more details that are left out of a sim or model, the easier the code is to write and cheaper to produce.				
(C) This option is correct. Less detailed models or sims take less compute time allowing for more iteration.				
(D) This option is incorrect. MORE abstract models or sims omit details not less abstract models and sims.				

44. Which of the following statements about data analysis and processing are considered most true given modern computing technology?

Select two answers.

- (A) Data scientists typically do not combine multiple data sources as more can be learned when each data source is analyzed independently.
- (B) Metadata is not included in modern data analysis as there is not useful information in metadata.
- (C) Information cleansing and classification are often employed in the processing of data by which patterns can emerge.
- (D) Storage, processing, or curation often present significant challenge when processing large datasets.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
3.1 People use computer programs to process information and 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	3.1.1B	2
(A) This option is incorrect. Data scientists often combine data sets to find new insights that could not be found in the individual datasets.				
(B) This option is incorrect. Metadata can increase the effective use of data or datasets by providing additional useful information.				
(C) This option is correct. Both processes (cleaning and classification) are valid techniques employed by data scientists.				
(D) This option is correct. Many times all of these are an issue in big data analysis. One of these are almost certainly going to present as a problem in a large data analysis problem (see EK 3.2.2.B)				

45. You are given a 32-bit word which was copied from computer RAM and are asked to determine what was represented by the word. Which of the following represents the most complete response?

- I. The 32-bit word could be integer data as binary is how data is always represented in RAM.
- II. The 32-bit word could be an instruction for the CPU as hardware processes binary words.
- III. We cannot be certain as to what the word represented without more information.

- (A) I only
- (B) II only
- (C) I and II
- (D) I, II and III

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.1 A variety of abstractions built on binary sequences can be used to represent all digital data.	2.1.2 Explain how binary sequences are used to represent digital data.	P5 Abstracting	2.1.1D	3
(A) This option is incorrect. While the word could have been integer data, there are many other types the word could have represented.				
(B) This option is incorrect. Not unlike choice A, while this is a possibility it is not the most complete response.				
(C) This option is incorrect. Both of these are possible but the word could have been other types like String, double or list data.				
(D) This option is correct. At a minimum, we would need the preceding type to narrow down how the word should have been interpreted.				

46. Which of the following statements is NOT correct regarding abstraction as applied to computer science:

- (A) Higher level languages utilize abstraction to hide details of the CPU instructions from the programmer.
- (B) A computer chip is often an abstraction of many lower level logic gates and memory combined to perform a specific function.
- (C) Binary sequences are abstractions which are used to represent colors in an image.
- (D) Smaller programs and apps can be combined into large programs to create higher level abstractions.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.	2.2.3 Identify multiple levels of abstractions that are used when writing programs.	P3 Abstracting	2.2.3G	2
(A) This option is incorrect. Higher level languages DO hide the details of lower level languages from the programmer. A CPU instruction set is considered a low-level language.				
(B) This option is incorrect. Many computer chips combiner thousands of logic gates and memory to perform functions.				
(C) This option is correct. Pixels are abstractions of RGB data which are in turn abstractions of binary sequences.				
(D) This option is incorrect. Smaller programs, apps, functions, and procedures are often combined to make larger programs making this statement true.				

47. Which code segment will compute (and store) the product of all the numbers contained in the list, numList, assuming there is at least one item in the list?

- (A)

```
product ← 1
FOR EACH item IN numList {
    product ← product + item
}
```
- (B)

```
product ← 1
FOR EACH num IN numList {
    product ← product * num
}
```
- (C)

```
product ← 1
REPEAT UNTIL (numList) {
    product ← product * num
}
```
- (D)

```
product ← 1
REPEAT LENGTH(numList) TIMES {
    product ← product * num
}
```

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
4.1 Algorithms are precise sequences of instructions.	4.1.1 Develop an algorithm for implementation.	P4 Analyzing problems and artifacts	4.1.1A	3
(A) This option is incorrect because it computes the sum, not the product.				
(B) This option is correct because it will compute the product of all the numbers in the list. If the list has zero items in it, it is arguable that the algorithm produces an incorrect product. If the list contains non-numeric items, it is arguable the algorithm will result in an incorrect behavior (error).				
(C) This option is incorrect because the condition is invalid. The repeat loop will not iterate correctly for various numList contents. However, if the list has one and only one number -- which is the number (1) one -- the algorithm <i>might</i> produce the correct product. The language definition is a bit unclear what happens when using a non-boolean expression in a repeat block.				
(D) This option is incorrect because the variable num is undefined.				

48. You were hired as a manager of a set of new programmers because of your experience in generating quality code. One of your new programmers brings a solution which looks nothing like what you would generate for the same problem. Which of the following might be a good next step?

- I. Analyze the solution for correctness and readability.
- II. Realize that there are multiple ways to solve most problems and work to understand this employee's solution.
- III. If the program includes sequence, selection, and iterative statements, assume the solution is correct and congratulate her for her outstanding contribution.

- (A) I only
- (B) I and II only
- (C) II and III only
- (D) I, II and III

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
2.3 Multiple levels of abstraction are used to write programs or create other computational artifacts	2.2.3 Identify multiple levels of abstractions being used when writing programs	P3 Abstracting	2.2.3A	3
(A) This option is incorrect. Although you should analyze the solution for correctness and readability, you should also be open to realizing that there are multiple ways to solve a problem. Hence, it's not the most correct answer.				
(B) This option is correct. In this scenario, the manager has verified (tested) correctness and has recognized a different yet viable solution. The key is that the solution has been tested and confirmed as viable.				
(C) This option is incorrect. In this scenario, although it's excellent management to recognizing that there are multiple ways to solve a problem without verifying the solution you are not guaranteed a correct solution. Simply having iteration, etc. does not guarantee a correct solution.				
(D) This option is incorrect. You should never assume a solution is correct without verifying (testing). Simply having iteration, etc. does not guarantee a correct solution.				

49. How many bits are used in the address of an IPv4 packet?

- (A) 4
- (B) 16
- (C) 32
- (D) 128

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
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	6.1.1E	1
(A) This option is incorrect. $2^4 = 16$; insufficient to accommodate all devices on the internet.				
(B) This option is incorrect. $2^{16} = 65536$; insufficient to accommodate all devices on the internet.				
(C) This option is correct. $2^{32} \approx 4.3$ billion addresses - sufficient for the initial years of the internet.				
(D) This option is incorrect. $2^{128} \approx 3.4 \times 10^{38}$ addresses - this is the IPv6 address definition.				

50. Which one of these would be least likely to make programming code easily modifiable in the future?

- (A) Using meaningful variable names which reflect the purpose of the data that is stored in them.
- (B) Combining duplicated code into one procedure.
- (C) Creating more procedures for the program.
- (D) Increasing the number of comments in your code by which others can understand the program and why you implemented it that way.

Enduring Understandings	Learning Objectives	Computational Thinking Practices	Essential Knowledge	Difficulty
EU 5.4 Programs are developed, maintained, and used by people for different purposes	5.4.1 Evaluate the correctness of a program.	P4 Analyzing Programs and Artifacts	5.4.1A	3
(A) This option is incorrect. Using meaningful variable names that reflect the purpose of the data can help a programmer understand and modify the code if needed.				
(B) This option is incorrect. Combining duplicated code into one procedure reduces the number of potential bugs in the program.				
(C) This option is correct. Creating more procedures for the program increases the complexity of the program and makes it less modifiable.				
(D) This option is incorrect. Commenting one's code allows a programmer to understand the purpose of the code and allows for the programmer to easily modify the code later.				

