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Chapter 1: An Introduction to Computer Science

TRUE/FALSE

1. The evolution of computer science began before the development of the first computer system.

   ANS: T PTS: 1 REF: 2

2. Computer science is the study of computers.

   ANS: F PTS: 1 REF: 2

3. Computer science is the study of how to write computer programs.

   ANS: F PTS: 1 REF: 3

4. Algorithms are exclusive to the field of computer science.

   ANS: F PTS: 1 REF: 7

5. All conceivable problems can be solved algorithmically.

   ANS: F PTS: 1 REF: 11

6. Algorithms usually contain a set of instructions to be executed in any order.

   ANS: F PTS: 1 REF: 12

7. When an operation is unambiguous, we call it a primitive operation, or simply a primitive of the computing agent carrying out the algorithm.

   ANS: T PTS: 1 REF: 13-14

8. Mechanical devices for performing complex calculations existed prior to the 20th century.

   ANS: T PTS: 1 REF: 18-19

9. Hollerith's machines were one of the first examples of the use of automated information processing to solve large-scale, real-world problems.

   ANS: T PTS: 1 REF: 22

10. The first electronic programmable computer, ENIAC, was built during World War I.

    ANS: F PTS: 1 REF: 24-25

MODIFIED TRUE/FALSE

1. According to Norman Gibbs' and Allen Tucker's definition of computer science, the central concept in computer science is the compiler. ____________________

   ANS: F, algorithm

PTS: 1 REF: 5

2. The statement: “If the mixture is too dry, then add one-half cup of water to the bowl” is an example of a(n) iterative operation. ____________________

ANS: F, conditional

PTS: 1 REF: 7

3. The discovery by Gödel places a limit on the capabilities of computers and computer scientists. ____________________

ANS: T PTS: 1 REF: 10

4. The Analytic Engine was the first computing device to use the base-2 binary numbering system. ____________________

ANS: F
Mark I
Harvard Mark I

PTS: 1 REF: 24

5. FORTRAN and COBOL, the first high-level (“English-like”) programming languages, appeared during the first generation of computing. ____________________

ANS: F, second

PTS: 1 REF: 29

COMPLETION

1. The three types of ____________________ used to construct algorithms are sequential, conditional, and iterative.

ANS: operations

PTS: 1 REF: 6-7

2. One of the most fundamentally important virtues of a(n) ____________________ is that if we can specify one to solve a problem, then we can automate the solution.

ANS: algorithm

PTS: 1 REF: 10

3. Leibniz’s ____________________ could carry out addition, subtraction, multiplication, and division.

ANS: Wheel

PTS: 1 REF: 19

4. Charles Babbage gave up on his second ____________________ because the current technology could not support his project.

   ANS: Difference Engine

   PTS: 1 REF: 21

5. Wireless communications are a(n) ____________________-generation innovation in computing.

   ANS: fifth

   PTS: 1 REF: 31

MULTIPLE CHOICE

1. In theoretical computer science, researchers study the logical and ____ of problems and their solutions.
   a. mathematical properties
   b. difficulty level
   c. mathematical uniqueness
   d. mathematical formulation

   ANS: A PTS: 1 REF: 2-3

2. ____ is one of the most common applications of computers.
   a. Searching a list
   b. Running a company
   c. Writing a program
   d. Generating a list of all the prime numbers

   ANS: A PTS: 1 REF: 4

3. Designing programming languages and translating algorithms into these languages is known as ____ realization.
   a. programming language
   b. compiler
   c. linguistic
   d. interpreter

   ANS: C PTS: 1 REF: 6

4. A(n) ____ instruction carries out a single well-defined task.
   a. sequential
   b. conditional
   c. iterative
   d. hierarchal

   ANS: A PTS: 1 REF: 6

5. In computer science terminology, the machine, robot, person, or thing carrying out the steps of the algorithm is called a(n) ____.
   a. computing agent
   b. algorithmic agent
   c. computing representative
   d. algorithmic representative

   ANS: A PTS: 1 REF: 10

6. An algorithm is essentially useless when ____.
   a. it’s difficult to read
   b. it takes too long to execute
   c. it takes too long to create
   d. people might be offended by the results

   ANS: B PTS: 1 REF: 10

7. A(n) ____ is a well-ordered collection of unambiguous and effectively computable operations that, when executed, produces a result and halts in a finite amount of time.

   a. sequence
   b. computing agent
   c. mechanical calculator
   d. algorithm

   ANS: D PTS: 1 REF: 11

8. An operation that is unambiguous is called a ____ operation of the computing agent carrying out the algorithm.

   a. primary
   b. complementary
   c. basic
   d. primitive

   ANS: D PTS: 1 REF: 13-14

9. What is wrong with the following algorithm?

   1. Set X to be 1
   2. Increment X
   3. Print X
   4. If X > 0, repeat from 2

   a. It does not produce a result.
   b. It is ambiguous.
   c. It does not halt in a finite amount of time.
   d. It is not well-ordered.

   ANS: C PTS: 1 REF: 15

10. Automation of repetitive mental tasks was part of a movement known as the ____ revolution.

   a. industrial
   b. technological
   c. computer
   d. designer

   ANS: C PTS: 1 REF: 17

11. The history of mathematics begins ____ years ago.

   a. 250
   b. 1,000
   c. 2,000
   d. 3,000 or more

   ANS: D PTS: 1 REF: 18

12. In 1672, a French philosopher and mathematician designed and built one of the first mechanical calculators named the ____ that could do addition and subtraction.

   a. Pascaline
   b. Leibniz Wheel
   c. abacus
   d. TI-85

   ANS: A PTS: 1 REF: 18

13. The first slide rule appeared around ____.

   a. 1183
   b. 1622
   c. 1882
   d. 1945

   ANS: B PTS: 1 REF: 18

14. In 1614, John Napier invented ____ as a way to simplify difficult mathematical computations.

   a. algorithms
   b. logarithms
   c. electronic computers
   d. mechanical calculators

   ANS: B PTS: 1 REF: 18

15. ____ was the first programmable device.
    a. A Leibniz Wheel
    b. The Analytic Engine
    c. The Pascaline
    d. Jacquard's loom

    ANS: D PTS: 1 REF: 21

16. In Babbage's analytical engine, a mill was used to ____.
    a. store memory
    b. process instructions
    c. perform arithmetic operations
    d. accept input

    ANS: C PTS: 1 REF: 22

17. The ____ was the first fully electronic general-purpose programmable computer.
    a. EDVAC
    b. EDSAC
    c. ENIAC
    d. Mark I

    ANS: C PTS: 1 REF: 24-25

18. In 1946, John Von Neumann proposed a radically different computer design based on a model called the ____ computer.
    a. stored program
    b. external program
    c. programmable function
    d. memory unit

    ANS: A PTS: 1 REF: 26

19. Integrated circuits, built on silicon chips, were introduced during the ____ generation of computing.
    a. first
    b. second
    c. third
    d. fourth

    ANS: C PTS: 1 REF: 29

20. During the ____ generation of computing, the desktop machine shrunk to the size of a typewriter.
    a. first
    b. second
    c. third
    d. fourth

    ANS: D PTS: 1 REF: 29

SHORT ANSWER

1. Briefly respond to the observation that every problem can be solved algorithmically, and discuss the implications of your response.

   ANS:
   While it might seem that every problem can be solved algorithmically, in the early 1930s the German logician Kurt Gödel proved that there are problems for which no generalized algorithmic solution can possibly exist. No matter how much time and effort is put into obtaining a solution to these problems, they are unsolvable and no solution will ever be found. This discovery, which staggered the mathematical world, effectively places a limit on the ultimate capabilities of computers and computer scientists.

   PTS: 1 REF: 10 TOP: Critical Thinking

2. Explain the meaning and significance of the term "effectively computable."

ANS:
It is not enough for an operation to be understandable; it must also be doable by the computing agent. If an algorithm tells me to flap my arms really quickly and fly, while I understand perfectly what it is asking me to do, I am incapable of doing it. "Doable" means there exists a computational process that allows the computing agent to complete that operation successfully, the formal term for which is "effectively computable."

PTS: 1 REF: 14 TOP: Critical Thinking

3. What was the major change brought about by the second generation of computing?

ANS:
In the late 1950s, the bulky vacuum tube of the first generation of computers was replaced by a single transistor only a few millimeters in size, and memory was now constructed using tiny magnetic cores only 1/50 of an inch in diameter, drastically changing the size and complexity of computers.

PTS: 1 REF: 29 TOP: Critical Thinking

4. What were the marks of the user-friendly systems that emerged in the fourth generation of computers?

ANS:
They included new graphical user interfaces with pull-down menus, icons, and other visual aids to make computing easier and more fun.

PTS: 1 REF: 31 TOP: Critical Thinking

5. What are embedded systems?

ANS:
Embedded systems are devices that contain a computer system that is designed to control internal operations to specifically perform one or two dedicated functions. Examples of embedded systems are cell phones, certain military weapon systems, dishwashers, GPS receivers, traffic lights, and emergency room equipment.

PTS: 1 REF: 31 TOP: Critical Thinking

ESSAY

1. Respond to the observation that computer science is the study of how to write computer programs. Include an example to illustrate your argument.

ANS:
Many people are introduced to computer science when learning to write programs in a language such as C++, Python, or Java. This almost universal use of programming as the entry to the discipline can create the misunderstanding that computer science is equivalent to computer programming.

Programming is extremely important to the discipline—researchers use it to study new ideas and build and test new solutions—but like the computer itself, it is a tool. When computer scientists design and analyze a new approach to solving a problem or create new ways to represent information, they often implement their ideas as programs to test them on an actual computer system. This enables researchers to see how well these new ideas work and whether they perform better than previous methods.

For example, searching a list is one of the most common applications of computers, and it is frequently applied to huge problems, such as finding one name among the approximately 20,000,000 listings in the New York City telephone directory. A more efficient lookup method could significantly reduce the time that customers must wait for directory assistance. Assume that we have designed what we believe to be a "new and improved" search technique. After analyzing it theoretically, we would study it empirically by writing a program to implement our new method, executing it on our computer, and measuring its performance. These tests would demonstrate under what conditions our new method is or is not faster than the directory search procedures currently in use.

In computer science, it is not simply the construction of a quality program that is important but also the methods it embodies, the services it provides, and the results it produces. It is possible to become so enmeshed in writing code and getting it to run that we forget that a program is only a means to an end, not an end in itself.

PTS: 1 REF: 3-4 TOP: Critical Thinking

2. Define each of the categories to which the operations used to construct algorithms belong. Provide two to three examples within each category

ANS:
All the operations used to construct algorithms belong to one of only three categories:
Sequential operations A sequential instruction carries out a single well-defined task. When that task is finished, the algorithm moves on to the next operation. Sequential operations are usually expressed as simple declarative sentences.
• Add 1 cup of butter to the mixture in the bowl.
• Subtract the amount of the check from the current account balance.
• Set the value of x to 1.

Conditional operations These are the "question-asking" instructions of an algorithm. They ask a question, and the next operation is selected on the basis of the answer to that question.
• If the mixture is too dry, then add one-half cup of water to the bowl.
• If the amount of the check is less than or equal to the current account balance, then cash the check; otherwise, tell the person there are insufficient funds.
• If x is not equal to 0, then set y equal to 1/x; otherwise, print an error message that says you cannot perform division by 0.

Iterative operations These are the "looping" instructions of an algorithm. They tell us not to go on to the next instruction but, instead, to go back and repeat the execution of a previous block of instructions.
• Repeat the previous two operations until the mixture has thickened.
• While there are still more checks to be processed, do the following five steps.
• Repeat Steps 1, 2, and 3 until the value of y is equal to 1.

PTS: 1 REF: 6-7 TOP: Critical Thinking

3. Explain the achievement of the Difference Engine of Charles Babbage, and explain the challenge he confronted in trying to construct the larger model.

ANS:

In 1823, Babbage extended the ideas of Pascal and Leibniz and constructed a working model of the largest and most sophisticated mechanical calculator of its time. This machine, called the Difference Engine, could do addition, subtraction, multiplication, and division to 6 significant digits, and it could solve polynomial equations and other complex mathematical problems as well. Babbage tried to construct a larger model of the Difference Engine that would be capable of working to an accuracy of 20 significant digits, but after 12 years of work he had to give up his quest. The technology available in the 1820s and 1830s was not sufficiently advanced to manufacture cogs and gears to the precise tolerances his design required. Like Galileo's helicopter or Jules Verne's atomic submarine, Babbage's ideas were fundamentally sound but years ahead of their time. (In 1991, the London Museum of Science, using Babbage's original plans, built an actual working model of the Difference Engine. It worked exactly as Babbage had planned.)

PTS: 1 REF: 21 TOP: Critical Thinking

4. Explain the significance of the Von Neumann architecture.

ANS:
In 1946, John Von Neumann proposed a radically different computer design based on a model called the stored program computer. Until then, all computers were programmed externally using wires, connectors, and plugboards. The memory unit stored only data, not instructions. For each different problem, users had to rewire virtually the entire computer. For example, the plugboards on the ENIAC contained 6,000 separate switches, and reprogramming the ENIAC involved specifying the new settings for all these switches—not a trivial task.

Von Neumann proposed that the instructions that control the operation of the computer be encoded as binary values and stored internally in the memory unit along with the data. To solve a new problem, instead of rewiring the machine, you would rewrite the sequence of instructions—that is, create a new program. Von Neumann invented programming as it is known today. The model of computing proposed by Von Neumann included many other important features found on all modern computing systems, and to honor him this model of computation has come to be known as the Von Neumann architecture.

PTS: 1 REF: 26 TOP: Critical Thinking

5. List at least six of the recent developments in computer systems.

ANS:
Some of the recent developments in computer systems include the following:
• Massively parallel processors capable of quadrillions of computations per second
• Smartphones, tablets, and other types of handheld digital devices
• High-resolution graphics for imaging, animation, movie making, video games, and virtual reality
• Powerful multimedia user interfaces incorporating sound, voice recognition, touch, photography, video, and television
• Integrated digital devices incorporating data, television, telephone, camera, the Internet, the World Wide Web and, struggling for relevancy, the fax
• Wireless communications
• Massive storage devices capable of holding 100 petabytes of data
• Ubiquitous computing, in which miniature computers are embedded into our cars, cameras, kitchen appliances, home heating systems, clothing, and even our bodies

PTS: 1 REF: 31 TOP: Critical Thinking