ETS®

GRE®

GRADUATE RECORD EXAMINATIONS®

Computer Science Test Practice Book

This practice book contains

- one actual full-length GRE Computer Science Test
- test-taking strategies

Become familiar with

- test structure and content
- test instructions and answering procedures

Compare your practice test results with the performance of those who took the test at a GRE administration.

Visit GRE Online at www.gre.org

Listening.
Learning.
Leading.

This book is provided FREE with test registration by the Graduate Record Examinations Board.

Note to Test Takers: Keep this practice book until you receive your score report. The book contains important information about content specifications and scoring.

Table of Contents

Purpose of the GRE Subject Tests

The GRE Subject Tests are designed to help graduate school admission committees and fellowship sponsors assess the qualifications of applicants in specific fields of study. The tests also provide you with an assessment of your own qualifications.

Scores on the tests are intended to indicate knowledge of the subject matter emphasized in many undergraduate programs as preparation for graduate study. Because past achievement is usually a good indicator of future performance, the scores are helpful in predicting success in graduate study. Because the tests are standardized, the test scores permit comparison of students from different institutions with different undergraduate programs. For some Subject Tests, subscores are provided in addition to the total score; these subscores indicate the strengths and weaknesses of your preparation, and they may help you plan future studies.

The GRE Board recommends that scores on the Subject Tests be considered in conjunction with other relevant information about applicants. Because numerous factors influence success in graduate school, reliance on a single measure to predict success is not advisable. Other indicators of competence typically include undergraduate transcripts showing courses taken and grades earned, letters of recommendation, the GRE Writing Assessment score, and GRE General Test scores. For information about the appropriate use of GRE scores, write to GRE Program, Educational Testing Service, Mail Stop 57-L, Princeton, NJ 08541, or visit our Web site at www.gre.org/codelst.html.

Development of the Subject Tests

Each new edition of a Subject Test is developed by a committee of examiners composed of professors in the subject who are on undergraduate and graduate faculties in different types of institutions and in different regions of the United States and Canada. In selecting members for each committee, the GRE Program seeks the advice of the appropriate professional associations in the subject.

The content and scope of each test are specified and reviewed periodically by the committee of examiners. Test questions are written by the committee and by other faculty who are also subject-matter specialists and by subject-matter specialists at ETS. All questions proposed for the test are reviewed by the committee and revised as necessary. The accepted questions are assembled into a test in accordance with the content specifications developed by the committee to ensure adequate coverage of the various aspects of the field and, at the same time, to prevent overemphasis on any single topic. The entire test is then reviewed and approved by the committee.

Subject-matter and measurement specialists on the ETS staff assist the committee, providing information and advice about methods of test construction and helping to prepare the questions and assemble the test. In addition, each test question is reviewed to eliminate language, symbols, or content considered potentially offensive, inappropriate for major subgroups of the test-taking population, or likely to perpetuate any negative attitude that may be conveyed to these subgroups. The test as a whole is also reviewed to ensure that the test questions, where applicable, include an appropriate balance of people in different groups and different roles.

Because of the diversity of undergraduate curricula, it is not possible for a single test to cover all the material you may have studied. The examiners, therefore, select questions that test the basic knowledge and skills most important for successful graduate study in the particular field. The committee keeps the test up-to-date by regularly developing new editions and revising existing editions. In this way, the test content changes steadily but gradually, much like most curricula. In addition, curriculum surveys are conducted periodically to ensure that the content of a test reflects what is currently being taught in the undergraduate curriculum.

After a new edition of a Subject Test is first administered, examinees' responses to each test question are analyzed in a variety of ways to determine whether each question functioned as expected. These analyses may reveal that a question is ambiguous, requires knowledge beyond the scope of the test, or is inappropriate for the total group or a particular subgroup of examinees taking the test. Answers to such questions are not used in computing scores.

Following this analysis, the new test edition is equated to an existing test edition. In the equating process, statistical methods are used to assess the difficulty of the new test. Then scores are adjusted so that examinees who took a difficult edition of the test are not penalized, and examinees who took an easier edition of the test do not have an advantage. Variations in the number of questions in the different editions of the test are also taken into account in this process.

Scores on the Subject Tests are reported as three-digit scaled scores with the third digit always zero. The maximum possible range for all Subject Test total scores is from 200 to 990. The actual range of scores for a particular Subject Test, however, may be smaller. The maximum possible range of Subject Test subscores is 20 to 99; however, the actual range of subscores for any test or test edition may be smaller than 20 to 99. Subject Test score interpretive information is provided in *Interpreting Your GRE Scores,* which you will receive with your GRE score report, and on the GRE Web site at www.gre.org/codelst.html.

Content of the Computer Science Subject Test

The test consists of about 70 multiple-choice questions, some of which are grouped in sets and based on such materials as diagrams, graphs, and program fragments.

The approximate distribution of questions in each edition of the test according to content categories is indicated by the following outline. The percentages given are approximate; actual percentages will vary slightly from one edition of the test to another.

I. SOFTWARE SYSTEMS AND METHODOLOGY — 40%
   - A. Data organization
     1. Data types
     2. Data structures and implementation techniques
   - B. Program control and structure
     1. Iteration and recursion
     2. Procedures, functions, methods, and exception handlers
     3. Concurrency, communication, and synchronization
   - C. Programming languages and notation
     1. Constructs for data organization and program control
     2. Scope, binding, and parameter passing
     3. Expression evaluation

D. Software engineering
   1. Formal specifications and assertions
   2. Verification techniques
   3. Software development models, patterns, and tools
E. Systems
   1. Compilers, interpreters, and run-time systems
   2. Operating systems, including resource management and protection/security
   3. Networking, Internet, and distributed systems
   4. Databases
   5. System analysis and development tools

II. COMPUTER ORGANIZATION AND ARCHITECTURE — 15%
A. Digital logic design
   1. Implementation of combinational and sequential circuits
   2. Optimization and analysis
B. Processors and control units
   1. Instruction sets
   2. Computer arithmetic and number representation
   3. Register and ALU organization
   4. Data paths and control sequencing
C. Memories and their hierarchies
   1. Performance, implementation, and management
   2. Cache, main, and secondary storage
   3. Virtual memory, paging, and segmentation
D. Networking and communications
   1. Interconnect structures (e.g., buses, switches, routers)
   2. I/O systems and protocols
   3. Synchronization
E. High-performance architectures
   1. Pipelining superscalar and out-of-order execution processors
   2. Parallel and distributed architectures

III. THEORY AND MATHEMATICAL BACKGROUND — 40%
A. Algorithms and complexity
   1. Exact and asymptotic analysis of specific algorithms
   2. Algorithmic design techniques (e.g., greedy, dynamic programming, divide and conquer)
   3. Upper and lower bounds on the complexity of specific problems
   4. Computational complexity, including NP-completeness
B. Automata and language theory
   1. Models of computation (finite automata, Turing machines)
   2. Formal languages and grammars (regular and context-free)
   3. Decidability
C. Discrete structures
   1. Mathematical logic
   2. Elementary combinatorics and graph theory
   3. Discrete probability, recurrence relations, and number theory

IV. Other Topics — 5%
Example areas include numerical analysis, artificial intelligence, computer graphics, cryptography, security, and social issues.

Note: Students are assumed to have a mathematical background in the areas of calculus and linear algebra as applied to computer science.

Preparing for a Subject Test

GRE Subject Test questions are designed to measure skills and knowledge gained over a long period of time. Although you might increase your scores to some extent through preparation a few weeks or months before you take the test, last-minute cramming is unlikely to be of further help. The following information may be helpful.

- A general review of your college courses is probably the best preparation for the test. However, the test covers a broad range of subject matter, and no one is expected to be familiar with the content of every question.

- Use this practice book to become familiar with the types of questions in the GRE Computer Science Test, paying special attention to the directions. If you thoroughly understand the directions before you take the test, you will have more time during the test to focus on the questions themselves.

Test-Taking Strategies

The questions in the practice test in this book illustrate the types of multiple-choice questions in the test. When you take the test, you will mark your answers on a separate machine-scorable answer sheet. Total testing time is two hours and fifty minutes; there are no separately timed sections. Following are some general test-taking strategies you may want to consider.

- Read the test directions carefully, and work as rapidly as you can without being careless. For each question, choose the best answer from the available options.
- All questions are of equal value; do not waste time pondering individual questions you find extremely difficult or unfamiliar.
- You may want to work through the test quite rapidly, first answering only the questions about which you feel confident, then going back and answering questions that require more thought, and concluding with the most difficult questions if there is time.
- If you decide to change an answer, make sure you completely erase it and fill in the oval corresponding to your desired answer.
- Questions for which you mark no answer or more than one answer are not counted in scoring.
- As a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly is subtracted from the number of questions you answer correctly. It is improbable that mere guessing will improve your score significantly; it may even lower your score. If, however, you are not certain of the correct answer but have some knowledge of the question and are able to eliminate one or more of the answer choices, your chance of getting the right answer is improved, and it may be to your advantage to answer the question.
- Record all answers on your answer sheet. Answers recorded in your test book will not be counted.
- Do not wait until the last five minutes of a testing session to record answers on your answer sheet.

What Your Scores Mean

Your raw score–that is, the number of questions you answered correctly minus one-fourth of the number you answered incorrectly–is converted to the scaled score that is reported. This conversion ensures that a scaled score reported for any edition of a Subject Test is comparable to the same scaled score earned on any other edition of the same test. Thus, equal scaled scores on a particular Subject Test indicate essentially equal levels of performance regardless of the test edition taken. Test scores should be compared only with other scores on the same Subject Test. (For example, a 680 on the Computer Science Test is not equivalent to a 680 on the Mathematics Test.)

Before taking the test, you may find it useful to know approximately what raw scores would be required to obtain a certain scaled score. Several factors influence the conversion of your raw score to your scaled score, such as the difficulty of the test edition and the number of test questions included in the computation of your raw score. Based on recent editions of the Computer Science Test, the table on the next page gives the range of raw scores associated with selected scaled scores for three different test editions. (Note that when the number of scored questions for a given test is greater than the number of possible scaled scores, it is likely that two or more raw scores will convert to the same scaled score.) The three test editions in the table that follows were selected to reflect varying degrees of difficulty. Examinees should note that future test editions may be somewhat more or less difficult than the test editions illustrated in the table.

Range of Raw Scores* Needed to Earn Selected Scaled Scores on Three Computer Science Test Editions That Differ in Difficulty

Scaled Score	Raw Scores		
	Form A	Form B	Form C
800	47	41-42	37-38
700	31	27	22-23
600	16-17	15	11
500	3-4	3	0
Number of Questions Used to Compute Raw Score			
	70	69	67

*Raw Score = Number of correct answers minus one-fourth the number of incorrect answers, rounded to the nearest integer.

For a particular test edition, there are many ways to earn the same raw score. For example, on the edition listed above as “Form A,” a raw score of 31 would earn a scaled score of 700. Below are a few of the possible ways in which a scaled score of 700 could be earned on that edition.

Examples of Ways to Earn a Scaled Score of 700 on the Edition Labeled as “Form A”

Raw Score	Questions Answered Correctly	Questions Answered Incorrectly	Questions Not Answered	Number of Questions Used to Compute Raw Score
31	31	0	39	70
31	34	12	24	70
31	38	28	4	70

Practice Test

To become familiar with how the administration will be conducted at the test center, first remove the answer sheet (pages 51 and 52). Then go to the back cover of the test book (page 46) and follow the instructions for completing the identification areas of the answer sheet. When you are ready to begin the test, note the time and begin marking your answers on the answer sheet.

FORM GR0329

29

GRADUATE RECORD EXAMINATIONS®

COMPUTER SCIENCE TEST

Do not break the seal
until you are told to do so.

The contents of this test are confidential.
Disclosure or reproduction of any portion
of it is prohibited.

THIS TEST BOOK MUST NOT BE TAKEN FROM THE ROOM.

COMPUTER SCIENCE TEST
Time—170 minutes
70 Questions

Notation, Conventions, and Definitions:

In this test a reading knowledge of modern programming languages is assumed. The following notational conventions and definitions are used.

1. All numbers are assumed to be written in decimal notation unless otherwise indicated.
2. $\lfloor x \rfloor$ denotes the greatest integer that is less than or equal to x.
3. $\lceil x \rceil$ denotes the least integer that is greater than or equal to x.
4. $g(n) = O(f(n))$ denotes "$g(n)$ has order at most $f(n)$" and means that there exist positive constants C and N such that $|g(n)| \le Cf(n)$ for all $n > N$.

   $g(n) = \Omega(f(n))$ denotes "$g(n)$ has order at least $f(n)$" and for this test means that there exist positive constants C and N such that $g(n) \ge Cf(n)$ for all $n > N$.

   $g(n) = \Theta(f(n))$ denotes "$g(n)$ has the same order as $f(n)$" and means that there exist positive constants C_1, C_2, and N such that $C_1 f(n) \le g(n) \le C_2 f(n)$ for all $n > N$.
5. $\exists$ denotes "there exists."

   $\forall$ denotes "for all."

   $\rightarrow$ denotes "implies;" $\supset$ is also used to denote "implies;" and $\Rightarrow$ is also used to denote "implies."

   $\neg$ denotes "not"; "$\overline{A}$" is also used as meaning "$\neg A$."

   $\vee$ denotes "inclusive or"; $+$ also denote "inclusive or," e.g., $P + Q$ can denote "P or Q."

   $\oplus$ denotes "exclusive or."

   $\wedge$ denotes "and"; also, juxtaposition of statements can denote "and," e.g., PQ can denote "P and Q."

   A boolean formula is <u>satisfiable</u> if it is true under some assignment of boolean values for its variables.

   A boolean formula is a <u>tautology</u> (or is <u>valid</u>) if it is true under all assignments of boolean values for its variables.
6. $\varnothing$ denotes the empty set.

   If A and B denote sets, then:

   $A \cup B$ is the set of all elements that are in A or in B or in both;

   $A \cap B$ is the set of all elements that are in both A and B;

   $\overline{A}$ is the set of all elements not in A that are in some specified universal set.

   $|A|$ is the cardinality of A.
7. In a string expression, if S and T denote strings or sets of strings, then:

   An empty string is denoted by ϵ or by Λ;

   ST denotes the concatenation of S and T;

   $S + T$ denotes $S \cup T$ or $\{S, T\}$, depending on context;

   S^n denotes $\underbrace{SS\ldots S}_{n \text{ factors}}$;

   S^* denotes $\epsilon + S + S^2 + S^3 + \ldots$;

   S^+ denotes $S + S^2 + S^3 + \ldots$.

8. In a grammar:

$\alpha \to \beta$ represents a production in the grammar.

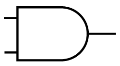
$\alpha \Rightarrow \beta$ means β can be derived from α by the application of exactly one production.

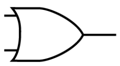
$\alpha \overset{*}{\Rightarrow} \beta$ means β can be derived from α by the application of zero or more productions.

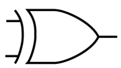
Unless otherwise specified,

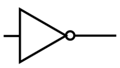
(i) symbols appearing on the left-hand side of productions are nonterminal symbols; the remaining symbols are terminal symbols;
(ii) the leftmost symbol of the first production is the start symbol; and
(iii) the start symbol is permitted to appear on the right-hand side of productions.

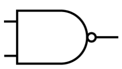
9. In a logic diagram:

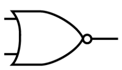
 represents an AND gate.

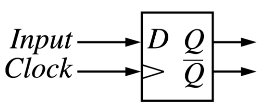
 represents an inclusive OR gate.

 represents an exclusive OR gate.

 represents a NOT gate.

 represents a NAND gate.

 represents a NOR gate.

10. 

represents a D-type flip-flop, which stores the value of its D input when clocked.

11. Binary tree traversal is defined recursively as follows.

Preorder: visit the root, traverse the left subtree, traverse the right subtree
Inorder: traverse the left subtree, visit the root, traverse the right subtree
Postorder: traverse the left subtree, traverse the right subtree, visit the root

12. In a finite automaton diagram, states are represented by circles, with final (or accepting) states indicated by two concentric circles. The start state is labeled "Start". An arc from state s to state t labeled a indicates a transition from s to t on input a. A label a/b indicates that this transition produces an output b. A label $a_1, a_2, \ldots, a_k$ indicates that the transition is made on any of the inputs $a_1, a_2, \ldots, a_k$.

13. For a program segment S and predicates P and Q, to say that the triple $\{P\}S\{Q\}$ is <u>partially correct</u> means that if P is true before initiation of S, then Q is true upon termination of S. To say that $\{P\}S\{Q\}$ is <u>totally correct</u> means that it is partially correct and S terminates for all inputs for which P is true.

Given that $\{P\}S\{Q\}$ is partially correct, a <u>precondition</u> is any assertion that implies P, and a <u>postcondition</u> is any assertion that is implied by Q.

14. A <u>loop invariant</u> for a `while` statement

`while` B `do` S

is an assertion that is true each time the guard B is evaluated during execution of the `while` statement.

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is the best of the choices offered and then mark the corresponding space on the answer sheet.

1. Suppose that a certain software product has a mean time between failures of 10,000 hours and has a mean time to repair of 20 hours. If the product is used by 100 customers, what is its availability?

   (A) 80% (B) 90% (C) 98% (D) 99.8% (E) 100%

---

2. The object-oriented paradigm includes which of the following properties?

   I. Encapsulation

   II. Inheritance

   III. Recursion

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

---

3. Which of the following algorithms has running time $\Theta\left(n^2\right)$ in the worst case but $\Theta(n \log n)$ on average?

(A) Bubblesort

(B) Mergesort

(C) Heapsort

(D) Quicksort

(E) Tournament sort

---

4. Which of the following is the name of the data structure in a compiler that is responsible for managing information about variables and their attributes?

(A) Abstract Syntax Tree (AST)

(B) Attribute Grammar

(C) Symbol Table

(D) Semantic Stack

(E) Parse Table

GO ON TO THE NEXT PAGE.

5. Consider the following pseudocode.

```
x := 1;
i := 1;
while (x ≤ 1000)
begin
  x := 2^x;
  i := i + 1;
end;
```

What is the value of `i` at the end of the pseudocode?

(A) 4

(B) 5

(C) 6

(D) 7

(E) 8

---

6. Suppose that $P(x, y)$ means "x is a parent of y" and $M(x)$ means "x is male". If $F(v, w)$ equals

$$M(v) \wedge \exists x \, \exists y \left(P(x, y) \wedge P(x, v) \wedge (y \neq v) \wedge P(y, w) \right),$$

what is the meaning of the expression $F(v, w)$?

(A) v is a brother of w.

(B) v is a nephew of w.

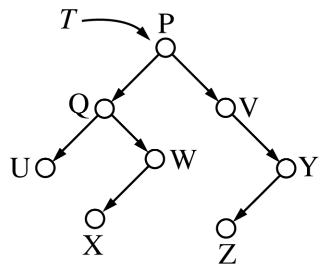
(C) v is an uncle of w.

(D) v is a grandfather of w.

(E) v is a male cousin of w.

GO ON TO THE NEXT PAGE.

Questions 7-8 are based on binary tree T shown below.



7. Which of the following represents a postorder traversal of T ?

   (A) P Q U W X V Y Z

   (B) U Q X W P V Z Y

   (C) U X W Q Z Y V P

   (D) U X Z Q W Y V P

   (E) X Z U W Y Q V P

8. If T is a binary search tree with the smaller elements in the left subtree, which of the following nodes contains the fourth smallest element in T ?

   (A) Q (B) V (C) W (D) X (E) Z

---

9. Which of the following statements about Ethernets is typically FALSE?
   (A) Ethernets use circuit switching to send messages.
   (B) Ethernets use buses with multiple masters.
   (C) Ethernet protocols use a collision-detection method to ensure that messages are transmitted properly.
   (D) Networks connected by Ethernets are limited in length to a few hundred meters.
   (E) Packets sent on Ethernets are limited in size.

---

10. A k-ary tree is a tree in which every node has at most k children. In a k-ary tree with n nodes and height h, which of the following is an upper bound for the maximum number of leaves as a function of h, k, and n ?

(A) $\log_k n$ (B) $\log_k h$ (C) $\dfrac{n}{\log_k n}$ (D) k^h (E) h^k

---

11. Which of the following is (are) true about virtual memory systems that use pages?
    I. The virtual address space can be larger than the amount of physical memory.
    II. Programs must be resident in main memory throughout their execution.
    III. Pages correspond to semantic characteristics of the program.

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

---

12. Let $T(n)$ be defined by $T(1) = 7$ and $T(n+1) = 3n + T(n)$ for all integers $n \geq 1$. Which of the following represents the order of growth of $T(n)$ as a function of n ?

(A) $\Theta(n)$ (B) $\Theta(n \log n)$ (C) $\Theta(n^2)$ (D) $\Theta(n^2 \log n)$ (E) $\Theta(2^n)$

---

13. One approach to handling fuzzy logic data might be to design a computer using ternary (base-3) logic so that data could be stored as "true," "false," and "unknown." If each ternary logic element is called a flit, how many flits are required to represent at least 256 different values?

(A) 4 (B) 5 (C) 6 (D) 7 (E) 8

---

14. Hash tables can contribute to an efficient average-case solution for all of the problems described below EXCEPT:

(A) Counting distinct values: Given a set of n keys, determine the number of distinct key values.

(B) Dynamic dictionary: Support the operations of insert, delete, and search in a dictionary.

(C) Range search: Given values a and b, find all the records whose key value is in the range $[a, b]$.

(D) Symbol table lookup: Given a program identifier, find its type and address.

(E) Finding intersections: Given two sets of keys, find all key values in common to both sets.

---

15. An invariant for the loop below is "$z * x^k = b^n$ and $k \geq 0$".

```
x := b; k := n; z := 1;
while (k ≠ 0)
{
  if odd(k) then z := z*x;
  x := x*x;
  k := ⌊k/2⌋;
}
```

When the loop terminates, which of the following must be true?

(A) $x = b^n$ (B) $z = b^n$ (C) $b = x^n$ (D) $b = z^n$ (E) $k \neq 0$

---

16. In the Internet Protocol (IP) suite of protocols, which of the following best describes the purpose of the Address Resolution Protocol?

(A) To translate Web addresses to host names

(B) To determine the IP address of a given host name

(C) To determine the hardware address of a given host name

(D) To determine the hardware address of a given IP address

(E) To determine the appropriate route for a datagram

---

17. A certain pipelined RISC machine has 8 general-purpose registers `R0`, `R1`, . . . , `R7` and supports the following operations.

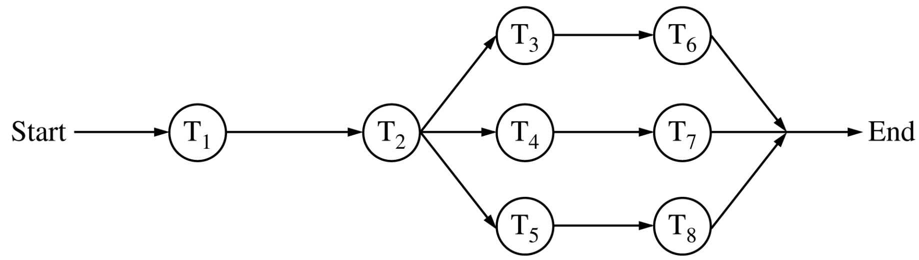
`ADD Rs1, Rs2, Rd`	Add `Rs1` to `Rs2` and put the sum in `Rd`
`MUL Rs1, Rs2, Rd`	Multiply `Rs1` by `Rs2` and put the product in `Rd`

An operation normally takes one cycle; however, an operation takes two cycles if it produces a result required by the immediately following operation in an operation sequence. Consider the expression $AB + ABC + BC$, where variables A, B, C are located in registers `R0`, `R1`, `R2`. If the contents of these three registers must not be modified, what is the minimum number of clock cycles required for an operation sequence that computes the value of $AB + ABC + BC$?

(A) 5 (B) 6 (C) 7 (D) 8 (E) 9

---

18. Below is a precedence graph for a set of tasks to be executed on a parallel processing system S.



Efficiency is defined as the ratio between the speedup and the number of processors. (The speedup is defined as the ratio of the time taken to perform a set of tasks on a single processor to the time taken to perform the same set of tasks on a parallel processor.)

System S has four processors (CPU's). If each of the tasks $T_1, \ldots, T_8$ takes the same time, what is the efficiency of this precedence graph on S?

(A) 25% (B) $33\frac{1}{3}$% (C) 50% (D) 100% (E) 125%

---

19. Let $G = (V, E)$ be a finite directed acyclic graph with $|E| > 0$. Which of the following must be true?

I. G has a vertex with no incoming edge.

II. G has a vertex with no outgoing edge.

III. G has an isolated vertex, that is, one with neither an incoming edge nor an outgoing edge.

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

Questions 20-21 are based on the following information.

Array `A` contains 256 elements of 4 bytes each. Its first element is stored at physical address 4,096.

Array `B` contains 512 elements of 4 bytes each. Its first element is stored at physical address 8,192.

Assume that only arrays `A` and `B` can be cached in an initially empty, physically addressed, physically tagged, direct-mapped, 2K-byte cache with an 8-byte block size. The following loop is then executed.

```
for (i = 0; i < 256; i++)
  A[i] = A[i] + B[2*i];
```

20. During the execution of the loop, how many bytes will be written to memory if the cache has a write-through policy?

(A) 0 (B) 256 (C) 1,024 (D) 2,048 (E) 4,096

21. During the execution of the loop, how many bytes will be written to memory if the cache has a write-back policy?

(A) 0 (B) 256 (C) 1,024 (D) 2,000 (E) 4,000

22. According to the IEEE standard, a 32-bit, single-precision, floating-point number N is defined to be

$$N = (-1)^S \times 1.F \times 2^{E-127}$$

where S is the sign bit, F the fractional mantissa, and E the biased exponent.

A floating-point number is stored as $S : E : F$, where S, E, and F are stored in 1 bit, 8 bits, and 23 bits, respectively. What is the decimal value of the floating-point number C1E00000 (hexadecimal notation) ?

(A) 26 (B) −15 (C) −26 (D) −28 (E) −59

---

23. Which of the following predicate calculus formulas must be true under all interpretations?

I. $\left(\forall x P(x) \vee \forall x Q(x)\right) \rightarrow \forall x\left(P(x) \vee Q(x)\right)$

II. $\forall x\left(P(x) \vee Q(x)\right) \rightarrow \left(\forall x P(x) \vee \forall x Q(x)\right)$

III. $\left(\exists x P(x) \vee \exists x Q(x)\right) \rightarrow \exists x\left(P(x) \vee Q(x)\right)$

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

Questions 24-25 are based on the following procedures.

```
procedure mystery
  a : integer;
  b : integer;

  procedure enigma(x,y)
  begin
    y = y + b;
    x = b + x;
    b = x + b;
    a = y;
  end enigma;

begin
  a = 2; b = 7;
  enigma(a,b);
  write(a); write(b);
end mystery;
```

The output of procedure `mystery` depends on the parameter-passing method used.

24. Suppose that all parameters are passed by value. Which of the following values are output when procedure `mystery` is called?

	a	b
(A)	2	7
(B)	2	9
(C)	9	14
(D)	14	16
(E)	30	30

25. Suppose that all parameters are passed by reference. Which of the following values are output when procedure `mystery` is called?

	a	b
(A)	2	7
(B)	2	9
(C)	9	14
(D)	14	16
(E)	30	30

26. Let A and B be two sets of words (strings) from Σ^*, for some alphabet of symbols Σ. Suppose that B is a subset of A. Which of the following statements must always be true of A and B ?

I. If A is finite, then B is finite.

II. If A is regular, then B is regular.

III. If A is context-free, then B is context-free.

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

---

27. A CPU has an arithmetic unit that adds bytes and then sets its V, C, and Z flag bits as follows. The V-bit is set if arithmetic overflow occurs (in two's complement arithmetic). The C-bit is set if a carry-out is generated from the most significant bit during an operation. The Z-bit is set if the result is zero. What are the values of the V, C, and Z flag bits after the 8-bit bytes 1100 1100 and 1000 1111 are added?

	V	C	Z
(A)	0	0	0
(B)	1	1	0
(C)	1	1	1
(D)	0	0	1
(E)	0	1	0

GO ON TO THE NEXT PAGE.

28. Let k be an integer greater than 1. Which of the following represents the order of growth of the expression $\sum_{i=1}^{n} k^i$ as a function of n ?

(A) $\Theta\left(k^n\right)$ (B) $\Theta\left(k^{n \log n}\right)$ (C) $\Theta\left(k^n \log n\right)$ (D) $\Theta\left(k^{2kn}\right)$ (E) $\Theta\left(n^{k+1}\right)$

---

29. Mergesort works by splitting a list of n numbers in half, sorting each half recursively, and merging the two halves. Which of the following data structures will allow mergesort to work in $O(n \log n)$ time?

I. A singly linked list

II. A doubly linked list

III. An array

(A) None (B) III only (C) I and II only (D) II and III only (E) I, II, and III

GO ON TO THE NEXT PAGE.

30. Consider the following function.

```
double power(double base, unsigned int exponent)
{
if (exponent == 0)
  return 1.0;
else
  if (even(exponent))
    return power(base*base, exponent/2);
  else
    return power(base*base, exponent/2)*base;
}
```

How many multiplications are executed as a result of the call `power(5.0, 12)` ? (Do not include divisions in this total.)

(A) 12 (B) 9 (C) 8 (D) 6 (E) 5

---

31. Which of the following statements about datagrams sent by a node in a network using IPv4 protocol is (are) true?

I. Datagrams at the source must be the size of the smallest maximum transmission unit (MTU) of all the links on a path to the destination.

II. Datagrams may be fragmented during routing.

III. Datagrams are reassembled only at the destination.

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

---

32. Of the following problems concerning a given undirected graph G, which is currently known to be solvable in polynomial time?

(A) Finding a longest simple cycle in G

(B) Finding a shortest cycle in G

(C) Finding ALL spanning trees of G

(D) Finding a largest clique in G

(E) Finding a node coloring of G (where adjacent nodes receive distinct colors) with the minimum number of colors

---

33. Two processors, M-5 and M-7, implement the same instruction set. Processor M-5 uses a 5-stage pipeline and a clock cycle of 10 nanoseconds. Processor M-7 uses a 7-stage pipeline and a clock cycle of 7.5 nanoseconds. Which of the following is (are) true?

I. M-7's pipeline has better maximum throughput than M-5's pipeline.

II. The latency of a single instruction is shorter on M-7's pipeline than on M-5's pipeline.

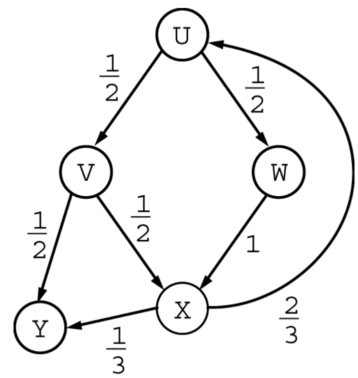
III. Programs executing on M-7 will always run faster than programs executing on M-5.

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

GO ON TO THE NEXT PAGE.

34. For the following code, the bias of each conditional branch in the code is labeled on the control flow graph to the right. For example, the Boolean expression `if_condition` evaluates to `true` on one-half of the executions of that expression.

```
do
{
  U;
  if (if_condition)
  {
    V;
    if (break_condition)
      break;
  }
  else
    W;
  X;
} while (loop_condition);
Y;
```



What is the expected number of times that `U` executes?

(A) 0.5

(B) 1

(C) 1.5

(D) 2

(E) More than 10

---

35. Consider the following grammar.

S → (S)
S → x

Which of the following statements is (are) true?

I. The grammar is ambiguous.

II. The grammar is suitable for top-down parsing.

III. The grammar is suitable for bottom-up parsing.

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

---

36. A logic circuit has three input bits: x_0, x_1, and x_2, where x_0 is the least significant bit and x_2 is the most significant bit. The output from the circuit is 1 when its input is any of the 3-bit numbers 1, 4, 5, or 6; otherwise, the output is 0. Which of the following expressions represents the output from this circuit?

(A) $\overline{x_2} + \overline{x_1} + \overline{x_0}$

(B) $\overline{x_2}\,x_0 + x_2\overline{x_1}$

(C) $\overline{x_1}\,x_0 + x_2\overline{x_0}$

(D) $\overline{x_2}\,x_1 x_0 + x_2\overline{x_1}$

(E) $x_2 + \overline{x_1}\,x_0$

---

37. Which of the following problems can be solved by a standard greedy algorithm?

I. Finding a minimum spanning tree in an undirected graph with positive-integer edge weights

II. Finding a maximum clique in an undirected graph

III. Finding a maximum flow from a source node to a sink node in a directed graph with positive-integer edge capacities

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

Questions 38-39 are based on the following information.

A certain randomized algorithm A is intended to determine whether a given positive-integer input n is prime by generating a random bit string r and, based on the values of n and r, by outputting either `Yes` (indicating that n is prime) or `No` (indicating that n is composite). Execution of algorithm A guarantees the following.

(i) If n is prime, then the output of A is always `Yes`.

(ii) If n is composite, then there is a probability $p > 0$ such that the output of A is `No` with probability p and is `Yes` with probability $1 - p$.

On an input m, algorithm A is executed k times ($k > 0$) and generates a random string r_i on the ith execution, $1 \leq i \leq k$, where $r_1, r_2, \ldots, r_k$ are mutually independent.

38. If m is composite, what is the probability that in each of the k different executions the output of A is `Yes` ?

(A) 1 (B) p^k (C) $(1 - p)^k$ (D) $1 - p^k$ (E) $1 - (1 - p)^k$

39. Suppose that in each of the k different executions the output of A is `No`. What is the probability that m is composite?

(A) 1 (B) p^k (C) $(1 - p)^k$ (D) $1 - p^k$ (E) $1 - (1 - p)^k$

40. In systems with support for automatic memory management, a garbage collector typically has the responsibility for reclaiming allocated memory objects whose contents cannot affect any future legal computation. Such objects are identified by determining that they cannot be reached from a root set. Which of the following is NOT part of the root set in a typical garbage collector?

(A) Actual parameters of the active procedures

(B) Dynamically allocated objects on the heap

(C) Global variables of the program

(D) Local variables on the call stack

(E) Values in machine registers

---

41. For a connected, undirected graph $G = (V, E)$, which of the following must be true?

I. $\sum_{v \in V} \text{degree}(v)$ is even.

II. $|E| \geq |V| - 1$

III. G has at least one vertex with degree 1.

(A) I only

(B) II only

(C) III only

(D) I and II

(E) II and III

---

42. Which of the following conditions can be expressed by a Boolean formula in the Boolean variables p_1, p_2, p_3, p_4 and the connectives $\wedge, \vee$ (without $\neg$) ?

I. At least three of p_1, p_2, p_3, p_4 are true.

II. Exactly three of p_1, p_2, p_3, p_4 are true.

III. An even number of p_1, p_2, p_3, p_4 are true.

(A) I only

(B) II only

(C) III only

(D) I and III

(E) II and III

---

43. Consider the collection of all undirected graphs with 10 nodes and 6 edges. Let M and m, respectively, be the maximum and minimum number of connected components in any graph in the collection. If a graph has no self-loops and there is at most one edge between any pair of nodes, which of the following is true?

(A) $M = 10,\ m = 10$

(B) $M = 10,\ m = 1$

(C) $M = 7,\ m = 4$

(D) $M = 6,\ m = 4$

(E) $M = 6,\ m = 3$

---

44. Consider the following pseudocode, where `n` is a nonnegative integer.

```
x = 0;
i = 0;
while i < n do
  x = x + 2^i;
  i = i + 1;
end
```

Which of the following is a loop invariant for the `while` statement? (Note: a loop invariant for a `while` statement is an assertion that is true each time the guard is evaluated during the execution of the `while` statement.)

(A) $x = 2^{i} - 1$ and $0 \le i < n$

(B) $x = 2^{i+1} - 1$ and $0 \le i < n$

(C) $x = 2^{i} - 1$ and $0 \le i \le n$

(D) $x = 2^{i+1} - 1$ and $0 \le i \le n$

(E) $x > 0$ and $1 \le i < n$

---

45. In order to find a solution x^* to the equation $f(x) = 0$ for a polynomial $f(x)$ of degree ≥ 2 with derivative $f'(x^*) \ne 0$, Newton's method does iterations of the form

$$x_{t+1} = x_t - \frac{f(x_t)}{f'(x_t)},$$

starting with some initial value $x_0 \ne x^*$ sufficiently close to the desired solution x^* to ensure convergence to x^*. For fixed values of x_0 and x^*, which of the following represents the order of growth of the minimal number of iterations required to compute x^* to b bits of accuracy as a function of b ?

(A) $O(1)$ (B) $O(\log \log b)$ (C) $O(\log b)$ (D) $O(\sqrt{b})$ (E) $O(b)$

---

46. Which of the following statements about a remote procedure call is true?

(A) It is used to call procedures with addresses that are farther than 2^{16} bytes away.

(B) It cannot return a value.

(C) It cannot pass parameters by reference.

(D) It cannot call procedures implemented in a different language.

(E) It is used to call procedures at an outer nesting level.

---

47. Let M be a single-tape, deterministic Turing machine with tape alphabet $\{blank, 0, 1\}$, and let C denote the (possibly infinite) computation of M starting with a blank tape. The input to each problem below is M, together with a positive integer n. Which of the following problems is (are) decidable?

I. The computation C lasts for at least n steps.

II. The computation C lasts for at least n steps, and M prints a 1 at some point after the nth step.

III. M scans at least n distinct tape squares during the computation C.

(A) None

(B) III only

(C) I and II only

(D) I and III only

(E) I, II, and III

---

48. Which of the following is NOT a property of bitmap graphics?

(A) Fast hardware exists to move blocks of pixels efficiently.

(B) Realistic lighting and shading can be done.

(C) All line segments can be displayed as straight.

(D) Polygons can be filled with solid colors and textures.

(E) The complexity of the image representation is independent of the image.

---

49. In a pipelined RISC computer where all arithmetic instructions have the same CPI (cycles per instruction), which of the following actions would improve the execution time of a typical program?

I. Increasing the clock cycle rate

II. Disallowing any forwarding in the pipeline

III. Doubling the sizes of the instruction cache and the data cache without changing the clock cycle time

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

Questions 50-51 refer to the following information.

The All Pairs Shortest Path Problem can be specified as follows.

Input:

Directed graph $G(V, E)$, where $V = \{1, 2, \ldots, n\}$

Cost $C(i, j) \in \mathbb{R}^+ \cup \{\infty\}$ for all $i, j \in V$, where $C(i, j) = \infty$ if and only if $(i, j) \notin E$

Definition:

$D(i, j)$ is the length of the shortest path from i to j for all $i, j \in V$.

If there is no path from i to j, then $D(i, j) = \infty$.

If $i = j$, then $D(i, j) = 0$.

Problem:

Find $D(i, j)$ for all $i, j \in V$.

The Floyd-Warshall algorithm gives a dynamic programming solution to the problem by defining an array $A(k, i, j)$ for $0 \le k \le n$ and $i, j \in V$ by the following condition.

$A(k, i, j)$ is the length of a shortest path from i to j such that all intermediate nodes on the path are in $\{1, 2, \ldots, k\}$ (where no intermediate nodes are allowed if $k = 0$).

Then $D(i, j) = A(n, i, j)$.

The algorithm computes $A(k, i, j)$ using a recurrence on k, where the initial step is given as follows.

$A(0, i, j) = C(i, j)$ for all $i, j \in V$ such that $i \neq j$

$A(0, i, i) = 0$ for all $i \in V$

50. Which of the following is the general step in the recurrence, where $1 \le k \le n$?

(A) $A(k, i, j) = \min_{\ell < k}\{A(\ell, i, k) + A(\ell, k, j)\}$

(B) $A(k, i, j) = \min_{\ell < k}\{A(k-1, i, \ell) + A(k-1, \ell, j)\}$

(C) $A(k, i, j) = \min\{A(k-1, i, j),\ A(k-1, i, k) + A(k-1, k, j)\}$

(D) $A(k, i, j) = \min\{C(i, j),\ A(k, i, k) + A(k, k, j)\}$

(E) $A(k, i, j) = \min\{C(i, j),\ A(k-1, i, k) + A(k-1, k, j)\}$

51. What is the running time of the Floyd-Warshall algorithm?

(A) $\Theta(n)$ (B) $\Theta(n^2)$ (C) $\Theta(n^3)$ (D) $\Theta(n^3 \log n)$ (E) $\Theta(n^4)$

52. A transaction schedule is serializable if its effect is equivalent to that of some serial schedule. Consider a bookkeeping operation consisting of two transactions — T_1 and T_2 — that are required to keep the sum `A + B + C` unchanged. Which of the following pairs of transactions will always result in a serializable schedule?

I.

T_1	T_2
`Lock A;`	`Lock B;`
`A = A - 10;`	`B = B - 20;`
`Unlock A;`	`Unlock B;`
`B = B + 10;`	`C = C + 20;`

II.

T_1	T_2
`A = A - 10;`	`Lock B;`
`Lock B;`	`B = B - 20;`
`B = B + 10;`	`Unlock B;`
`Unlock B;`	`C = C + 20;`

III.

T_1	T_2
`Lock A;`	`Lock A;`
`A = A - 10;`	`B = B - 20;`
`Unlock A;`	`Unlock A;`
`B = B + 10;`	`C = C + 20;`

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

53. Which of the following is NOT a reasonable justification for choosing to busy-wait on an asynchronous event?

(A) The wait is expected to be short.

(B) A busy-wait loop is easier to code than an interrupt handler.

(C) There is no other work for the processor to do.

(D) The task must meet some hard real-time deadlines.

(E) The program executes on a time-sharing system.

---

54. The Singleton design pattern is used to guarantee that only a single instance of a class may be instantiated. Which of the following is (are) true of this design pattern?

I. The Singleton class has a static factory method to provide its instance.

II. The Singleton class can be a subclass of another class.

III. The Singleton class has a private constructor.

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

GO ON TO THE NEXT PAGE.

55. Assume that a target `t` is an integer value stored in some element of integer array `x`, which is sorted in nondecreasing order, and consider the following outline of a loop to search for `t`.

```
<initialization of h and k>
while (x[h] ≠ t)
{
   P;
}
```

If `<initialization>` establishes the invariant "`x[h] ≤ t < x[k]`", which of the following definitions for `P`, taken individually, would ensure that the loop terminates with `x[h] = t`, assuming that `t` appears in the array?

I. `if x[h] < t then h := h + 1`

II. `h := h + 1`

III. `k := k - 1`

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

---

56. Assume that a debugger places a breakpoint at a load instruction at virtual address `0x77E81234` (hexadecimal notation) in a debugged process *P*. If the text segment of *P* begins at `0x77E80000` in *P*'s virtual address space and if the debugger has mapped this same text segment at `0x01000000` in its virtual address space, which of the following is the virtual address used by the debugger in its WRITE operation, along with a description of how the debugger has mapped the virtual memory page containing this address?

(A) `0x01001234;` page mapped with READ/WRITE access

(B) `0x01001234;` page mapped with COPY-ON-WRITE access

(C) `0x76E81234;` page mapped with READ/WRITE access

(D) `0x76E81234;` page mapped with COPY-ON-WRITE access

(E) `0x77E81234;` page mapped with READ/WRITE access

---

57. Company X shipped 5 computer chips, 1 of which was defective, and Company Y shipped 4 computer chips, 2 of which were defective. One computer chip is to be chosen uniformly at random from the 9 chips shipped by the companies. If the chosen chip is found to be defective, what is the probability that the chip came from Company Y?

(A) $\frac{2}{9}$ (B) $\frac{4}{9}$ (C) $\frac{1}{2}$ (D) $\frac{2}{3}$ (E) $\frac{5}{7}$

---

58. An Euler circuit of an undirected graph is a circuit in which each edge of the graph appears exactly once. Which of the following undirected graphs must have an Euler circuit?

I. A complete graph with 12 vertices

II. A complete graph with 13 vertices

III. A tree with 13 vertices

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

---

59. Consider the following two languages.

$$L_1 = \{x \in \{a, b\}^* \mid x \text{ has equally many } a\text{'s and } b\text{'s}\}$$
$$L_2 = \{x \in \{a, b, c\}^* \mid x \text{ has equally many } a\text{'s, } b\text{'s, and } c\text{'s}\}$$

Which of the following is true about L_1 and L_2?

(A) L_1 and L_2 are both regular.

(B) L_1 is regular, and L_2 is context-free but not regular.

(C) Neither L_1 nor L_2 is regular, but both are context-free.

(D) L_1 is context-free but not regular, and L_2 is not context-free.

(E) Neither L_1 nor L_2 is context-free.

---

60. Consider the following possible data structures for a set of n distinct integers.

I. A min-heap

II. An array of length n sorted in increasing order

III. A balanced binary search tree

For which of these data structures is the number of steps needed to find and remove the 7th largest element $O(\log n)$ in the worst case?

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

---

61. Which of the following problems is (are) decidable?

I. Given a (finite) string w, is w a prefix of the decimal expansion of π ?

II. Given a program and an input, is the program's output the decimal expansion of π ?

III. Given a program that takes as input a prefix of the decimal expansion of π, is the program's output always the same for every prefix?

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I, II, and III

GO ON TO THE NEXT PAGE.

62. Which of the following problems would have polynomial time algorithms if it is assumed that $\mathbf{P} \neq \mathbf{NP}$?

I. Given a combinational circuit with n inputs and m outputs and n^2 gates, where each gate is either AND, OR, or NOT, and given m values $c_1, \ldots, c_m$ in $\{0, 1\}$, either find a string of n input values $b_1, \ldots, b_n$ in $\{0, 1\}$ that would produce $c_1, \ldots, c_m$ as output or determine that $c_1, \ldots, c_m$ is not a possible output of the circuit.

II. Given an n by n matrix A with rational number entries, either find the <u>exact</u> inverse A^{-1} of A or determine that A^{-1} does not exist. (Assume that each rational number is expressed as a pair a/b of integers $(b \neq 0)$, where a and b are expressed in binary notation.)

III. Given a directed graph with nodes numbered 1, 2, . . . , n, and given positive integer weights assigned to the edges, either find the length of a shortest path from node 1 to node n or determine that no such path exists. (Here the <u>length</u> of a path is the sum of the lengths of the edge weights on the path.)

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

---

63. Which of the following characteristics of a programming language is best specified using a context-free grammar?

(A) Identifier length

(B) Maximum level of nesting

(C) Operator precedence

(D) Type compatibility

(E) Type conversion

64. Consider the following function.

```
f(k)
{
  x = 2;
  for i = 1 to k
    x = x * x;
  return x;
}
```

If n and k are positive integers, then the least value of k such that f(k) > n is approximately

(A) $\log_2(\log_2 n)$ (B) $\log_2 n$ (C) n (D) $n\log_2 n$ (E) 2^n

---

65. Let T be a depth-first search tree of a connected undirected graph G. For each vertex v of T, let
$pre(v)$ be the number of nodes visited up to and including v during a preorder traversal of T, and
$post(v)$ be the number of nodes visited up to and including v during a postorder traversal of T.

The lowest common ancestor of vertices u and v in T is a vertex w of T such that w is an ancestor of both u and v, and no child of w is an ancestor of both u and v.

Let (u, v) be an edge in G that is not in T, such that $pre(u) < pre(v)$. Which of the following statements about u and v must be true?

I. $post(u) < post(v)$

II. u is an ancestor of v in T.

III. If w is the lowest common ancestor of u and v in T, then $w = u$.

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

---

66. Consider languages L and L_1, each over the alphabet $\{a, b\}$, where

$$L_1 = \{w \mid w \text{ contains some } x \in L \text{ as a substring}\}.$$

Which of the following must be true about L and L_1 ?

I. If L is regular, then L_1 is regular.

II. If L is context-free, then L_1 is context-free.

III. If L is recursive, then L_1 is recursive.

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

---

67. For each nonnegative integer n, let R_n be the greatest possible number of regions into which the plane can be partitioned by n straight lines. For example, $R_0 = 1$ and $R_1 = 2$. Then R_n has order

(A) $\Theta(n)$

(B) $\Theta(n \log n)$

(C) $\Theta(n^2)$

(D) $\Theta(2^n)$

(E) $\Theta(n!)$

---

68. Which of the following comes closest to being a perfectly secure encryption scheme?

(A) The Caesar Cipher, a substitution cipher

(B) DES (Data Encryption Standard), a symmetric-key algorithm

(C) Enigma, a transposition cipher

(D) One-time pad

(E) RSA, a public-key algorithm

---

69. Suppose Q and R are languages. Assuming $\mathbf{P} \neq \mathbf{NP}$, which of the following implies that R is not in $\mathbf{P}$?

(A) R is in **NP**.

(B) Q is in **NP** and Q is polynomial-time reducible to R.

(C) Q is in **NP** and R is polynomial-time reducible to Q.

(D) Q is **NP**-complete and Q is polynomial-time reducible to R.

(E) Q is **NP**-complete and R is polynomial-time reducible to Q.

---

70. Let N be the set of all natural numbers. Which of the following sets are countable?

I. The set of all functions from N to $\{0, 1\}$

II. The set of all functions from $\{0, 1\}$ to N

III. The largest subset of N

(A) None (B) I and II only (C) I and III only (D) II and III only (E) I, II, and III

S T O P

If you finish before time is called, you may check your work on this test.

I

NOTE: To ensure prompt processing of test results, it is important that you fill in the blanks exactly as directed.

SUBJECT TEST

A. Print and sign your full name in this box:

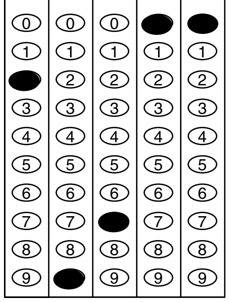
PRINT: ____
(LAST) (FIRST) (MIDDLE)

SIGN: ____

Copy this code in box 6 on your answer sheet. Then fill in the corresponding ovals exactly as shown.

6. TITLE CODE

2 9 7 0 0



Copy the Test Name and Form Code in box 7 on your answer sheet.

TEST NAME Computer Science

FORM CODE GR0329

GRADUATE RECORD EXAMINATIONS SUBJECT TEST

B. The Subject Tests are intended to measure your achievement in a specialized field of study. Most of the questions are concerned with subject matter that is probably familiar to you, but some of the questions may refer to areas that you have not studied.

Your score will be determined by subtracting one-fourth the number of incorrect answers from the number of correct answers. Questions for which you mark no answer or more than one answer are not counted in scoring. If you have some knowledge of a question and are able to rule out one or more of the answer choices as incorrect, your chances of selecting the correct answer are improved, and answering such questions will likely improve your score. It is unlikely that pure guessing will raise your score; it may lower your score.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult for you. Go on to the other questions and come back to the difficult ones later if you can.

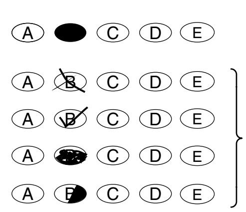
YOU MUST INDICATE ALL YOUR ANSWERS ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination book, but you may write in the book as much as you wish to work out your answers. After you have decided on your response to a question, fill in the corresponding oval on the answer sheet. BE SURE THAT EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. Mark only one answer to each question. No credit will be given for multiple answers. Erase all stray marks. If you change an answer, be sure that all previous marks are erased completely. Incomplete erasures may be read as intended answers. Do not be concerned that the answer sheet provides spaces for more answers than there are questions in the test.

Example:

What city is the capital of France?

(A) Rome
(B) Paris
(C) London
(D) Cairo
(E) Oslo

Sample Answer



CORRECT ANSWER PROPERLY MARKED

IMPROPER MARKS

DO NOT OPEN YOUR TEST BOOK UNTIL YOU ARE TOLD TO DO SO.

Educational Testing Service

Educational Testing Service
Princeton, New Jersey 08541

Scoring Your Subject Test

Computer Science Test scores typically range from 540 to 860. The range for different editions of a given test may vary because different editions are not of precisely the same difficulty. The differences in ranges among different editions of a given test, however, usually are small. This should be taken into account, especially when comparing two very high scores. In general, differences between scores at the 99th percentile should be ignored. The score conversion table on page 49 shows the score range for this edition of the test only.

The worksheet on page 48 lists the correct answers to the questions. Columns are provided for you to mark whether you chose the correct (C) answer or an incorrect (I) answer to each question. Draw a line across any question you omitted, because it is not counted in the scoring. At the bottom of the page, enter the total number correct and the total number incorrect. Divide the total incorrect by 4 and subtract the resulting number from the total correct. This is the adjustment made for guessing. Then round the result to the nearest whole number. This will give you your raw total score. Use the total score conversion table to find the scaled total score that corresponds to your raw total score.

Example: Suppose you chose the correct answers to 38 questions and incorrect answers to 22. Dividing 22 by 4 yields 5.5. Subtracting 5.5 from 38 equals 32.5, which is rounded to 33. The raw score of 33 corresponds to a scaled score of 760.

Worksheet for the Computer Science Test, Form GR0329 Only
Answer Key and Percentages* of Examinees Answering Each Question Correctly

QUESTION Number	QUESTION Answer	P +	TOTAL C	TOTAL I
1	D	65		
2	C	84		
3	D	71		
4	C	76		
5	B	70		
6	C	96		
7	**	**		
8	**	**		
9	A	41		
10	D	78		
11	A	68		
12	C	46		
13	C	76		
14	C	60		
15	B	69		
16	D	42		
17	B	48		
18	C	77		
19	D	71		
20	C	42		
21	A	25		
22	**	**		
23	D	41		
24	D	70		
25	E	72		
26	A	35		
27	B	63		
28	A	62		
29	E	27		
30	**	**		
31	E	45		
32	B	42		
33	A	55		
34	D	34		
35	D	49		

QUESTION Number	QUESTION Answer	P +	TOTAL C	TOTAL I
36	C	71		
37	A	32		
38	C	80		
39	A	47		
40	B	30		
41	D	47		
42	A	66		
43	C	65		
44	C	48		
45	C	18		
46	C	56		
47	D	33		
48	C	56		
49	E	60		
50	C	26		
51	C	36		
52	B	43		
53	E	33		
54	E	37		
55	D	71		
56	A	27		
57	D	68		
58	B	39		
59	D	38		
60	E	24		
61	A	53		
62	E	36		
63	C	52		
64	A	45		
65	E	18		
66	E	25		
67	**	**		
68	D	40		
69	D	35		
70	D	23		

Correct (**C**) ____________________

Incorrect (I) ____________________

Total Score:

C – I/4 = ____________

Scaled Score (SS) = ____________

* The P+ column indicates the percent of COMPUTER SCIENCE Test examinees who answered each question correctly; it is based on a sample of November 2003 examinees selected to represent all COMPUTER SCIENCE Test examinees tested between July 1, 2000 and June 30, 2003

** Items 7, 8, 22, 30, and 67 were not scored when this form of the test was originally administered.

Score Conversions and Percents Below*
For GRE Computer Science Test, Form GR0329 Only

TOTAL SCORE					
Raw Score	Scaled Score	%	Raw Score	Scaled Score	%
65	900	99	23	690	37
			22	680	34
61-64	890	99	21	670	31
57-60	880	98	20	660	28
53-56	870	97	19	650	25
50-52	860	95	17-18	640	22
48-49	850	93	16	630	20
46-47	840	91	15	620	18
44-45	830	87	14	610	16
42-43	820	84	13	600	14
40-41	810	82			
38-39	800	78	12	590	12
			11	580	10
37	790	74	10	570	8
35-36	780	71	9	560	7
34	770	67	8	550	6
32-33	760	63	7	540	5
31	750	58	6	53	4
29-30	740	55	5	520	3
28	730	51	4	510	3
27	720	47	2-3	500	2
26	710	44			
24-25	700	41	1	490	1
			0	480	1

* Percent scoring below the scaled score is based on the performance of 10,579 examinees who took the COMPUTER SCIENCE Test between July 1, 2000 and June 30, 2003.

Evaluating Your Performance

Now that you have scored your test, you may wish to compare your performance with the performance of others who took this test. Both the worksheet on page 48 and the table on page 49 use performance data from GRE Computer Science Test examinees.

The data in the worksheet on page 48 are based on the performance of a sample of the examinees who took this test in November 2003. This sample was selected to represent the total population of GRE Computer Science Test examinees tested between July 1, 2000 and June 30, 2003. The numbers in the column labeled “P+” on the worksheet indicate the percentages of examinees in this sample who answered each question correctly. You may use these numbers as a guide for evaluating your performance on each test question.

The table on page 49 contains, for each scaled score, the percentage of examinees tested between July 1, 2000 and June 30, 2003 who received lower scores. Interpretive data based on the scores earned by examinees tested in this three-year period will be used by admissions officers in the 2004-05 testing year. These percentages appear in the score conversion table in a column to the right of the scaled scores. For example, in the percentage column opposite the scaled score of 730 is the number 51. This means that 51 percent of the GRE Computer Science Test examinees tested between July 1, 2000 and June 30, 2003 scored lower than 730. To compare yourself with this population, look at the percentage next to the scaled score you earned on the practice test. *Note:* due to changes in the test-taking population, the percentile rank data changes over time. Percentile rank information is kept current on the GRE Web site and may be obtained by visiting the GRE Web at www.gre.org/codelst.html, or by contacting the GRE Program.

It is important to realize that the conditions under which you tested yourself were not exactly the same as those you will encounter at a test center. It is impossible to predict how different test-taking conditions will affect test performance, and this is only one factor that may account for differences between your practice test scores and your actual test scores. By comparing your performance on this practice test with the performance of other GRE Computer Science Test examinees, however, you will be able to determine your strengths and weaknesses and can then plan a program of study to prepare yourself for taking the GRE Computer Science Test under standard conditions.

DO NOT USE INK

Use only a pencil with soft, black lead (No. 2 or HB) to complete this answer sheet. Be sure to fill in completely the space that corresponds to your answer choice. Completely erase any errors or stray marks.

GRADUATE RECORD EXAMINATIONS® - GRE® - SUBJECT TEST

SIDE 1

1. NAME

Enter your last name, first name initial (given name), and middle initial if you have one. Omit spaces, apostrophes, Jr., II., etc.

Last Name only (Family or Surname) - first 15 letters | First Name Initial | Middle Initial

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

2.

YOUR NAME: ______________________
(Print) Last Name (Family or Surname) First Name (Given) M.I.

MAILING ADDRESS: ______________________
(Print) P.O. Box or Street Address

City State or Province

Country Zip or Postal Code

CENTER: ______________________
City State or Province

Country Center Number Room Number

SIGNATURE: ______________________

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ●

YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

1	A B C D E	39	A B C D E	77	A B C D E
2	A B C D E	40	A B C D E	78	A B C D E
3	A B C D E	41	A B C D E	79	A B C D E
4	A B C D E	42	A B C D E	80	A B C D E
5	A B C D E	43	A B C D E	81	A B C D E
6	A B C D E	44	A B C D E	82	A B C D E
7	A B C D E	45	A B C D E	83	A B C D E
8	A B C D E	46	A B C D E	84	A B C D E
9	A B C D E	47	A B C D E	85	A B C D E
10	A B C D E	48	A B C D E	86	A B C D E
11	A B C D E	49	A B C D E	87	A B C D E
12	A B C D E	50	A B C D E	88	A B C D E
13	A B C D E	51	A B C D E	89	A B C D E
14	A B C D E	52	A B C D E	90	A B C D E
15	A B C D E	53	A B C D E	91	A B C D E
16	A B C D E	54	A B C D E	92	A B C D E
17	A B C D E	55	A B C D E	93	A B C D E
18	A B C D E	56	A B C D E	94	A B C D E
19	A B C D E	57	A B C D E	95	A B C D E
20	A B C D E	58	A B C D E	96	A B C D E
21	A B C D E	59	A B C D E	97	A B C D E
22	A B C D E	60	A B C D E	98	A B C D E
23	A B C D E	61	A B C D E	99	A B C D E
24	A B C D E	62	A B C D E	100	A B C D E
25	A B C D E	63	A B C D E	101	A B C D E
26	A B C D E	64	A B C D E	102	A B C D E
27	A B C D E	65	A B C D E	103	A B C D E
28	A B C D E	66	A B C D E	104	A B C D E
29	A B C D E	67	A B C D E	105	A B C D E
30	A B C D E	68	A B C D E	106	A B C D E
31	A B C D E	69	A B C D E	107	A B C D E
32	A B C D E	70	A B C D E	108	A B C D E
33	A B C D E	71	A B C D E	109	A B C D E
34	A B C D E	72	A B C D E	110	A B C D E
35	A B C D E	73	A B C D E	111	A B C D E
36	A B C D E	74	A B C D E	112	A B C D E
37	A B C D E	75	A B C D E	113	A B C D E
38	A B C D E	76	A B C D E	114	A B C D E

Item responses continued on reverse side.

3. DATE OF BIRTH

Month	Day	Year
Jan.		
Feb.		
Mar.	0 0	0 0
April	1 1	1 1
May	2 2	2 2
June	3 3	3 3
July	4	4 4
Aug.	5	5 5
Sept.	6	6 6
Oct.	7	7 7
Nov.	8	8 8
Dec.	9	9

4. SOCIAL SECURITY NUMBER

(U.S.A. only)

0 1 2 3 4 5 6 7 8 9

5. REGISTRATION NUMBER

(from your admission ticket)

0 1 2 3 4 5 6 7 8 9

6. TITLE CODE

(on back cover of your test book)

0 1 2 3 4 5 6 7 8 9

7. TEST NAME (on back cover of your test book)

FORM CODE (on back cover of your test book)

8. TEST BOOK SERIAL NUMBER

(red number in upper right corner of front cover of your test book)

SHADED AREA FOR ETS USE ONLY

54074•02954•CV77P70ex 2 CHW94004 I.N.275470 Q2683-06/2

SIDE 2

SUBJECT TEST

COMPLETE THE CERTIFICATION STATEMENT, THEN TURN ANSWER SHEET OVER TO SIDE 1.

CERTIFICATION STATEMENT

Please write the following statement below, DO NOT PRINT.
"I certify that I am the person whose name appears on this answer sheet. I also agree not to disclose the contents of the test I am taking today to anyone."
Sign and date where indicated.

____

____

____

____

____

SIGNATURE: ______________________________ **DATE:** ____/____/____
Month Day Year

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ⬤.
YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

115	A	B	C	D	E	147	A	B	C	D	E	179	A	B	C	D	E	211	A	B	C	D	E
116	A	B	C	D	E	148	A	B	C	D	E	180	A	B	C	D	E	212	A	B	C	D	E
117	A	B	C	D	E	149	A	B	C	D	E	181	A	B	C	D	E	213	A	B	C	D	E
118	A	B	C	D	E	150	A	B	C	D	E	182	A	B	C	D	E	214	A	B	C	D	E
119	A	B	C	D	E	151	A	B	C	D	E	183	A	B	C	D	E	215	A	B	C	D	E
120	A	B	C	D	E	152	A	B	C	D	E	184	A	B	C	D	E	216	A	B	C	D	E
121	A	B	C	D	E	153	A	B	C	D	E	185	A	B	C	D	E	217	A	B	C	D	E
122	A	B	C	D	E	154	A	B	C	D	E	186	A	B	C	D	E	218	A	B	C	D	E
123	A	B	C	D	E	155	A	B	C	D	E	187	A	B	C	D	E	219	A	B	C	D	E
124	A	B	C	D	E	156	A	B	C	D	E	188	A	B	C	D	E	220	A	B	C	D	E
125	A	B	C	D	E	157	A	B	C	D	E	189	A	B	C	D	E	221	A	B	C	D	E
126	A	B	C	D	E	158	A	B	C	D	E	190	A	B	C	D	E	222	A	B	C	D	E
127	A	B	C	D	E	159	A	B	C	D	E	191	A	B	C	D	E	223	A	B	C	D	E
128	A	B	C	D	E	160	A	B	C	D	E	192	A	B	C	D	E	224	A	B	C	D	E
129	A	B	C	D	E	161	A	B	C	D	E	193	A	B	C	D	E	225	A	B	C	D	E
130	A	B	C	D	E	162	A	B	C	D	E	194	A	B	C	D	E	226	A	B	C	D	E
131	A	B	C	D	E	163	A	B	C	D	E	195	A	B	C	D	E	227	A	B	C	D	E
132	A	B	C	D	E	164	A	B	C	D	E	196	A	B	C	D	E	228	A	B	C	D	E
133	A	B	C	D	E	165	A	B	C	D	E	197	A	B	C	D	E	229	A	B	C	D	E
134	A	B	C	D	E	166	A	B	C	D	E	198	A	B	C	D	E	230	A	B	C	D	E
135	A	B	C	D	E	167	A	B	C	D	E	199	A	B	C	D	E	231	A	B	C	D	E
136	A	B	C	D	E	168	A	B	C	D	E	200	A	B	C	D	E	232	A	B	C	D	E
137	A	B	C	D	E	169	A	B	C	D	E	201	A	B	C	D	E	233	A	B	C	D	E
138	A	B	C	D	E	170	A	B	C	D	E	202	A	B	C	D	E	234	A	B	C	D	E
139	A	B	C	D	E	171	A	B	C	D	E	203	A	B	C	D	E	235	A	B	C	D	E
140	A	B	C	D	E	172	A	B	C	D	E	204	A	B	C	D	E	236	A	B	C	D	E
141	A	B	C	D	E	173	A	B	C	D	E	205	A	B	C	D	E	237	A	B	C	D	E
142	A	B	C	D	E	174	A	B	C	D	E	206	A	B	C	D	E	238	A	B	C	D	E
143	A	B	C	D	E	175	A	B	C	D	E	207	A	B	C	D	E	239	A	B	C	D	E
144	A	B	C	D	E	176	A	B	C	D	E	208	A	B	C	D	E	240	A	B	C	D	E
145	A	B	C	D	E	177	A	B	C	D	E	209	A	B	C	D	E	241	A	B	C	D	E
146	A	B	C	D	E	178	A	B	C	D	E	210	A	B	C	D	E	242	A	B	C	D	E

TR	TW	TFS	TCS	1R	1W	1FS	1CS	2R	2W	2FS	2CS
FOR ETS USE ONLY				3R	3W	3FS	3CS	4R	4W	4FS	4CS
				5R	5W	5FS	5CS	6R	6W	6FS	6CS

IF YOU DO NOT WANT THIS ANSWER SHEET TO BE SCORED

If you want to cancel your scores from this administration, complete A and B below. You will not receive scores for this test; however, you will receive confirmation of this cancellation. No record of this test or the cancellation will be sent to the recipients you indicated, and there will be no scores for this test on your GRE file. Once a score is canceled, it cannot be reinstated.

To cancel your scores from this test administration, you must:

A. fill in both ovals here . . . ◯ – ◯ B. sign your full name here: ______________

54721-007623 • U54E8 • Printed in U.S.A.
724474